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USDA Forest Service
General Technical Report INT-10
1973

Using the Effective Heating Number as a Weighting Factor in Rothermel's Fire Spread Model

William H. Frandsen

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INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION
Ogden, Utah 84401

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William H. Frandsen

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The Author

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Contents

INTRODUCTION 1
FIRE SPREAD MODEL INCONSISTENCY 2
THE SOLUTION 5
CONCLUSIONS 7

Abstract

An inconsistency arises in Rothermel's fire spread model when there are two or more categories. If a fuel load is split into identical classes in two separate categories, the reaction intensity is less than if the load is contained in a single class in one category. The author resolves the inconsistency by replacing the weighting parameter for each category with the effective heating number developed from the characteristic surface area-to-volume ratio of each category.

OXFORD: 431.5:431.6. KEYWORDS: ignitibility, fire behavior, fire spread model, effective heating number, weighting parameter.

Introduction

The formulations found in Rothermel's fire model[1] were derived from observations of fire spread through homogeneous fuel arrays. In order to correlate these data to heterogeneous fuel arrays, which are more often encountered in the field, Rothermel developed a method of "homogenizing" the fuel sizes into one characteristic size for each fuel type or category. The reaction intensity contribution from each category was then calculated and summed to give the total reaction intensity leading to the final calculation of the rate of spread.

The homogenizing process for combining either classes or categories was achieved by weighting each size class by its surface area. Thus, for equal loads, smaller diameter fuels are given greater weight to obtain the characteristic fuel size for that category.

My purpose is to show that if more than one category is used and identical fuels are entered or generated in each category, the weighting method will produce an inconsistency. The total reaction intensity and the resultant rate of spread will be less than if all the fuel were contained in one category. However, it follows that if a single category is used (e.g., dead fuel), no problems arise.

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[1] Richard C. Rothermel. A mathematical model for predicting fire spread in wildland fuels. USDA For. Serv. Res. Pap. INT-115, 40 p., illus. 1972.

Fire Spread Model Inconsistency

The problem is illustrated by using Rothermel's fire spread model to compute the rate of spread from the following list of fuel data:

Dry load	(0.034 lb./ft.^{2})
Low heat value	(8,000 B.t.u./lb.)
Fractional moisture content	(0.04 lb./lb.)
Fractional extinction moisture content	(0.30 lb./lb.)
Surface area-to-volume ratio	(3,500 ft.$^{-1}$)
Fractional mineral content	(0.06 lb./lb.)
Particle density	(32 lb./ft.^{3})
Effective fractional mineral content	(0.01 lb./lb.)
Fuel depth	(1 ft.)
Wind	(0 ft./min.)
Slope	(0 ft./ft.)

Two examples are given for comparison. First, the fuel load is entered into a *single* category, then *split* equally into two categories. The differing results are shown in table 1.

Table 1.--*Two computations of the rate of spread.*

Option	Reaction intensity			Rate of spread
	Category 1	Category 2	Total	
	B.t.u./ft.^{2}-min.			Ft./min.
Single *	1,070	--	1,070	6.4
Split †	267	267	534	3.2

*Load contained in one category.
†Load split equally into two categories.

The following illustrates this inconsistency algebraically. For a given size class, entering the load into one category gives twice the intensity of the same load equally divided into two categories. The differences occur in the weighting parameters in the reaction intensity equation (58).[1]

$$I_R = \Gamma' \sum_{i=1}^{i=m} f_i (\tilde{w}_n)_i (\tilde{h})_i (\tilde{\eta}_s)_i (\tilde{\eta}_m)_i ,$$

where,

$\tilde{w}_n$ = net load

$\tilde{h}$ = low heat value

$\tilde{\eta}_s$ = mineral damping coefficient

$\tilde{\eta}_m$ = moisture damping coefficient

$(\ )_i$ = in i^{th} category.

In the split load, the heat content, mineral damping, and moisture damping coefficients of each category are equivalent to their corresponding parameters in the single category. The weighting parameters of the split load are equal and each has a value of ½ because their sum must be 1. For one class in a single category there is one weighting factor, $f_i = 1$, and the reaction intensity is:

$$I_{Ra} = \Gamma' (\tilde{w}_n)_1 \tilde{h}_1 (\tilde{\eta}_s)_1 (\tilde{\eta}_m)_1 .$$

When the load is split equally into one class in each of two categories, the weighting parameters are:

$$f_1 = f_2 = \tfrac{1}{2},$$

so that,

$$I_{Rb} = \Gamma' [\tfrac{1}{2}(w_n/2)_1 \tilde{h}_1 (\tilde{\eta}_s)_1 (\tilde{\eta}_m)_1 + \tfrac{1}{2}(w_n/2)_2 \tilde{h}_2 (\tilde{\eta}_s)_2 (\tilde{\eta}_m)_2].$$

But,

$$(w_n/2)_1 \tilde{h}_1 (\tilde{\eta}_s)_1 (\tilde{\eta}_m)_1 = (w_n/2)_2 \tilde{h}_2 (\tilde{\eta}_s)_2 (\tilde{\eta}_m)_2 .$$

Therefore,

$$I_{Rb} = \Gamma' (w_n/2)_1 \tilde{h}_1 (\tilde{\eta}_s)_1 (\tilde{\eta}_m)_1$$

$$I_{Rb} = \tfrac{1}{2}\, \Gamma' (w_n)_1 \tilde{h}_1 (\tilde{\eta}_s)_1 (\tilde{\eta}_m)_1 ,$$

which gives:

$$I_{Rb} = \frac{1}{2}I_{Ra}.$$

But, since the load and fuel characteristics are equivalent, we should have:

$$I_{Rb} = I_{Ra}.$$

This argument can be expanded to n categories where the fraction of inequality is 1/n.

The above example is the worst case. The fraction I_{Rb}/I_{Ra} approaches 1 (completely consistent) as the fraction of the load in one category decreases from ½ to zero or increases from ½ to 1.

The Solution

To resolve this inconsistency the weighting parameter, f_i, was replaced by the effective heating number, evaluated from the characteristic surface area-to-volume ratio of each category. Explicitly, f_i in equation (58)[1] was replaced by

$$\varepsilon_i = \exp(-138/\tilde{\sigma}_i),$$

where $\tilde{\sigma}$ is the characteristic surface area-to-volume ratio of the i^{th} fuel category. Results using ε_i are given in table 2.

The general effect of exchanging the weighting parameter for the effective heating number is for the calculated rate of spread to increase if the fuel is distributed into more than one category (presently two, live and dead) and to decrease by a lesser

Table 2.--*Computations of the rate of spread modified by weighting the reaction intensity calculation by the effective heating number.*

Option	Reaction intensity			Rate of spread
	Category 1	Category 2	Total	
	B.t.u./ft.^{2}-min.			Ft./min.
Single*	1,028	--	1,028	6.2
Split †	514	514	1,028	6.2

*Load contained in one category

†Load split equally into two categories.

amount if the fuel is limited to one category. Figure 1 shows how three fuel models:[1] chaparral, timber (litter and understory), and slash (heavy, 200 T/A) are affected by exchanging the weighting parameter. The first two models, chaparral and timber, show increases when the effective heating number is used, whereas the slash model shows a decrease. Results are consistent with the fact that both fuel models, chaparral and timber, have two categories, live and dead, and slash has only one, dead.

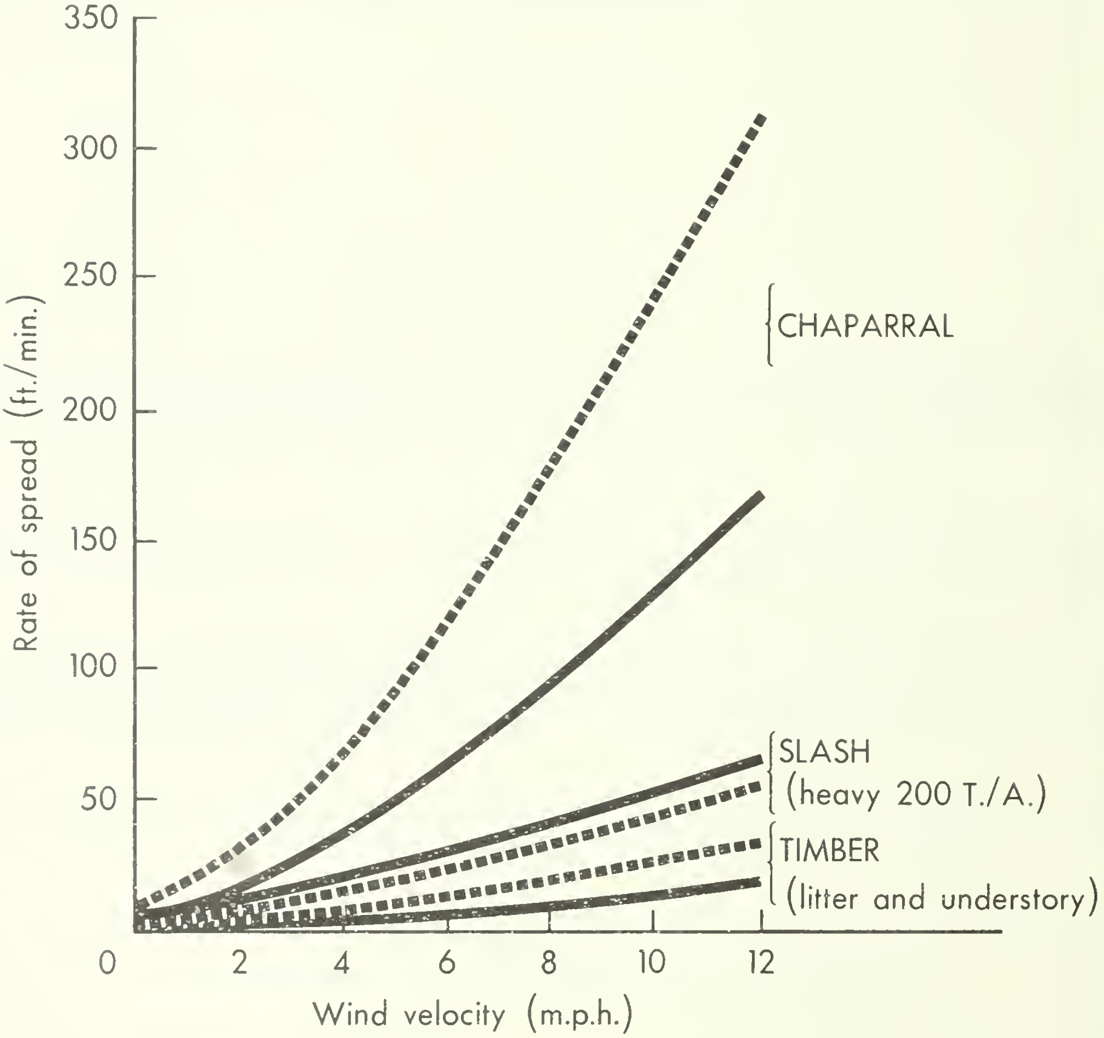

Figure 1.--Rate of fire spread versus wind velocity at midflame height for three fuel models:[1] *chaparral, timber (litter and understory), and slash (heavy, 200 T/A). The solid curves represent results of the weighting parameter, the dashed curves results of the effective heating number.*

Conclusions

By exchanging the weighting parameter for the effective heating number, the total reaction intensity and the rate of spread are less when the load is limited to a single category. However, the reverse is true when the load is divided into two categories. More importantly, when the effective heating number is used, the total reaction intensity and the rate of spread remain unchanged whether the load is divided into two or more categories or limited to one. Replacement of the weighting parameter, f_i, by the effective heating number, ε_i, is a reasonable alternative since it represents the fractional amount of fuel brought to ignition within the category. As used here, the effective heating number can account for the characteristic load effectively involved in the initial combustion process that creates the reaction intensity necessary to propagate the fire. It weights the category according to its characteristic fuel size and, consequently, its proportionate involvement in the spreading fire.

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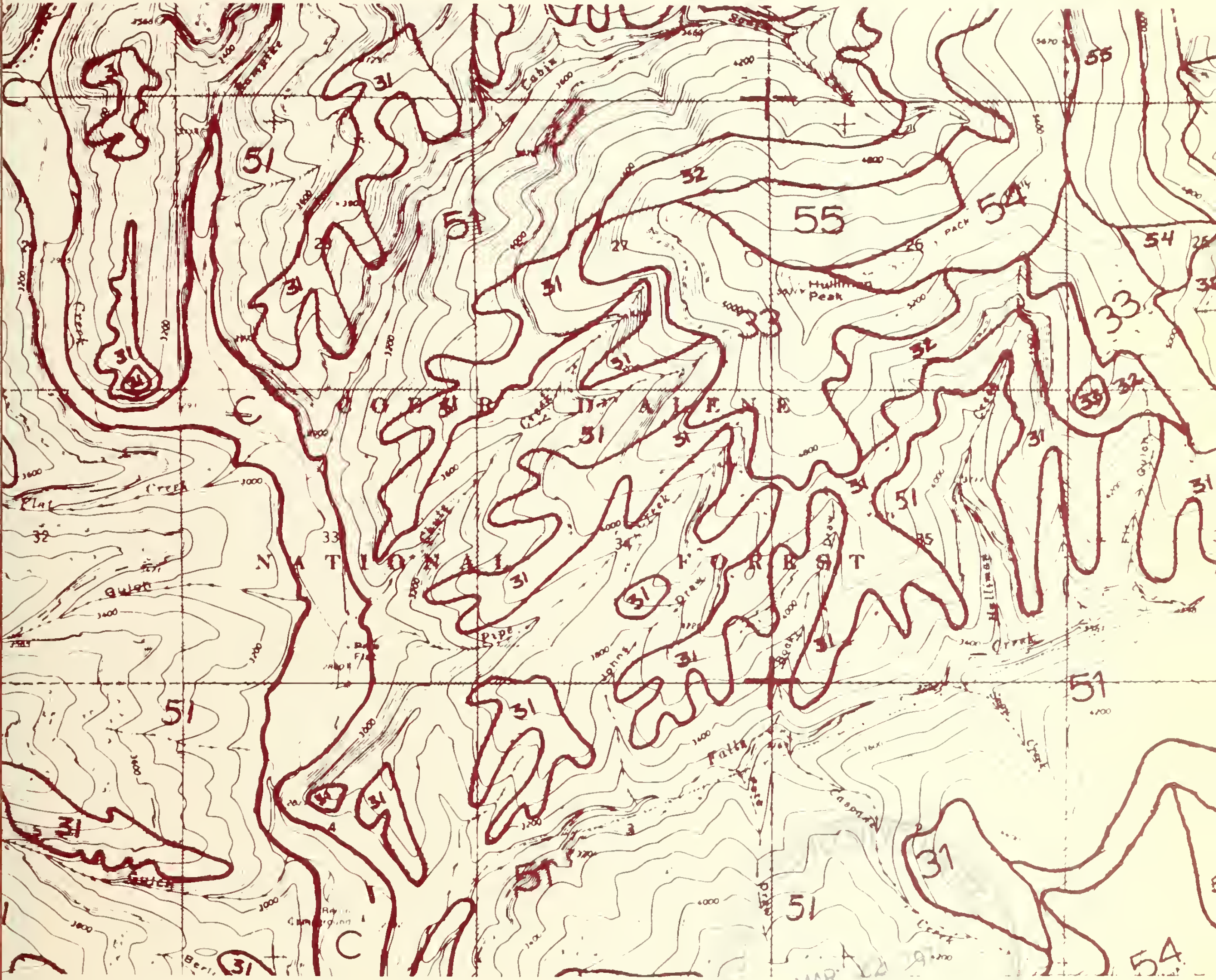
MAPPING OF HABITAT TYPES THROUGHOUT A NATIONAL FOREST

Glenn H. Deitschman



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Young Douglas-fir and ponderosa pine on a steep, thin-soiled, southerly slope that often characterized the occurrence of Douglas-fir/pachistima habitat type.

USDA Forest Service
General Technical Report INT-11
September 1973

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Special acknowledgment must be given to Ronald Brohman and Bernard Kovalchik (Regional Office) and to Harry S. Woffenden (Coeur d'Alene National Forest) for supervising and checking work of the field crews and for drafting most of the habitat type maps.

FOREWORD

Development of an ecosystem classification for the forest vegetations of the northern Rocky Mountains has provided land managers in this region with an effective means of stratifying the landscape into units of generally equivalent environment for plant growth. In recent years, the Northern Region of the USDA Forest Service has given increasing weight to habitat type identification in site descriptions for multiple use planning in specific stands.

In 1970, the opportunity arose to try mapping habitat types throughout an entire National Forest when a reinventory was made of timber resources on the Coeur d'Alene National Forest in northern Idaho. Procedures for fieldwork and mapping were developed as a joint endeavor by the Northern Region, the Coeur d'Alene National Forest, and the Intermountain Forest and Range Experiment Station.

ABSTRACT

The occurrence of ecologically defined habitat types over the entire Coeur d'Alene National Forest in northern Idaho was mapped in conjunction with a reinventory of the timber resource. This report describes the method of data collection and the observed relationships between habitat type occurrence and topographic variables that were used for interpretive mapping outside of sampled areas.

OXFORD: 182.2, 182.3, 182.58, 582.
KEYWORDS: Migration (plant), associations (plant), vegetation mapping methods, mapping, habitat type, ecosystem classification, topographic relationships.

CONTENTS

Page

Foreword iii

THE ENVIRONMENTAL SETTING 1

DEVELOPMENT OF MAPPING PROCEDURES 3

HABITAT TYPES ENCOUNTERED. 6

ENVIRONMENTAL INFLUENCES 7

    Effects of Geographic Location 7

    Effects of Landform 8

    Effects of Fire 10

PATTERN OF HABITAT TYPE OCCURRENCE 11

CONCLUSIONS 13

    Accuracy of Mapping 13

    Recommended Changes in Mapping Procedures 14

Typical terrain of Coeur d'Alene National Forest, showing some of the extensively developed logging road system.

THE ENVIRONMENTAL SETTING

The Coeur d'Alene National Forest contains about 723,000 acres. It extends from the Bitterroot Range on the east where elevations reach 6,800 feet above sea level to the edge of the Columbia Plateau on the west where the elevation drops to near 2,100 feet. The area between is occupied by the Coeur d'Alene Mountains, which resemble an intricately dissected highland. The terrain is generally steep; slopes of 50 to 65 percent are common. Most of the soils on the National Forest are brown Podzolic soils that have developed over rather hard argillite, quartzite, and sandstone and they usually display the influence of loess and volcanic ash mantles.

The climate is markedly influenced by maritime air masses brought in from the Pacific coast by prevailing westerly winds. This results in more cloudiness and precipitation as well as warmer mean temperatures than are experienced in areas farther east having continental climates. As Daubenmire[1] observed, the similarity of Northern Rocky Mountain climate to that of the west slope of the northern Cascades is attested to by the reappearance of western hemlock and western redcedar as climax forest at intermediate elevations. Precipitation at the city of Coeur d'Alene, on the west side of the National Forest, averages 26 inches per year; in the mountains, it increases about 14 inches for every rise of 1,000 feet in elevation. About 65 to 75 percent occurs as snow. Habitat types represented on the National Forest range from ponderosa pine associations on low elevation, dry sites to mainly subalpine fir and mountain hemlock at the highest sites (fig. 1).

---

[1] R. F. Daubenmire. Vegetational zonation in the Rocky Mountains. Bot. Rev. 9(6): 325-393, illus. 1943.

Pinus albicaulis/Abies lasiocarpa
(Whitebark pine/subalpine fir)

Tsuga mertensiana/Menziesia ferruginea
(Mountain hemlock/rusty menziesia)

Tsuga mertensiana/Xerophyllum tenax
(Mountain hemlock/beargrass)

Abies lasiocarpa/Menziesia ferruginea
(Subalpine fir/rusty menziesia)

Abies lasiocarpa/Vaccinium scoparium
(Subalpine fir/grouse whortleberry)

Abies lasiocarpa/Xerophyllum tenax
(Subalpine fir/beargrass)

Abies lasiocarpa/Pachistima myrsinites
(Subalpine fir/pachistima)

Pseudotsuga menziesii/Calamagrostis rubescens
(Douglas-fir/pinegrass)

Thuja plicata/Oplopanax horridum
(Western redcedar/devil's-club)

Thuja plicata/Athyrium filix-foemina
(Western redcedar/ladyfern)

Tsuga heterophylla/Pachistima myrsinites
(Western hemlock/pachistima)

Thuja plicata/Pachistima myrsinites
(Western redcedar/pachistima)

Abies grandis/Pachistima myrsinites
(Grand fir/pachistima)

Pseudotsuga menziesii/Physocarpus malvaceus
(Douglas-fir/ninebark)

Pinus ponderosa/Symphoricarpos albus
(Ponderosa pine/snowberry)

Pinus ponderosa/Festuca idahoensis
(Ponderosa pine/Idaho fescue)

Pinus ponderosa/Agropyron spicatum
(Ponderosa pine/bluebunch wheatgrass)

Figure 1.--Habitat types encountered on the Coeur d'Alene National Forest in general order of their expected occurrence on left-to-right gradients of increasing elevation, decreasing temperature, and (less conformably) increasing moisture.

DEVELOPMENT OF MAPPING PROCEDURES

Twenty-seven subcompartments or portions of subcompartments on the National Forest were selected for field sampling in 1971 in accordance with revised inventory system procedures that had been developed to provide "in-place" information on timber volume, growth, mortality, stand condition, and potential productivity.[2] The sampled units totaled about 23,000 acres, slightly over 3 percent of the entire Forest (fig. 2). As a part of the data collection in each of the subcompartments, the same field crews recorded habitat types at sample plot locations that systematically gridded the area at 5-chain intervals along lines 10 chains apart (a rate of about 1 plot per 5 acres). Written record of key vegetation presence and abundance was made at every fifth plot to facilitate supervisory checks on correctness of identification. Initial guidance for training the field crews was obtained from pioneer mapping of habitat types by Daubenmire at the Priest River Experimental Forest in 1967.[3]

For each subcompartment, the habitat type designations for each sample point were entered on a large-scale topographic map (4 inches = 1 mile; contour interval 40 or 80 feet. Using these designations as a base, lines were drawn where a change from one habitat type to another was indicated (fig. 3). Because of the low sampling intensity, no attempt was made to delineate broad ecotones or areas of less than 5 acres. This mapping of sampled units and of a few other areas within the National Forest where limited supplementary reconnaissance had been done confirmed that quite strong relationships existed among habitat type occurrence, geographic location, and certain topographic factors.

The map detail from the subcompartments and reconnoitered points subsequently were transferred to a set of smaller-scale topographic quadrangles (2" = 1 mile), each of which covered 7-1/2' or 15' of longitude and latitude. Using a more-or-less objective extrapolation of the previously determined geographic and topographic relationships to intervening areas, the remaining 96 percent-plus of the Forest then was mapped on the quadrangles as shown on front cover.

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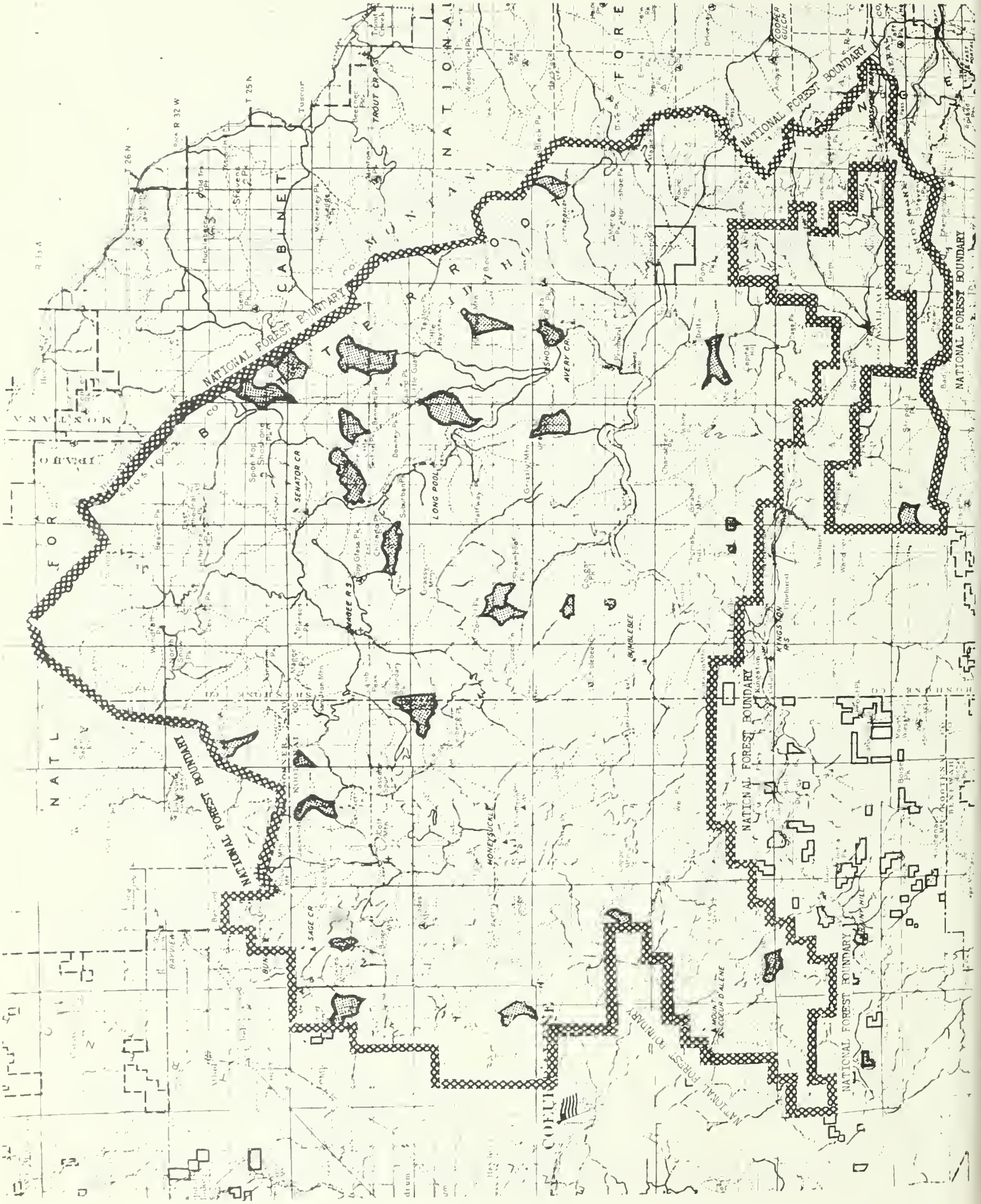
[2] Albert R. Stage and Jack R. Alley. An inventory design using stand examinations for planning and programing timber management. USDA For. Serv. Res. Pap. INT-126, 17 p., illus. 1972.

[3] R. F. Daubenmire. Habitat type mapping feasibility: a report on a cooperative agreement between the Forest Service and Washington State University. Typed report on file at Intermt. For. & Range Exp. Stn., Moscow, Idaho.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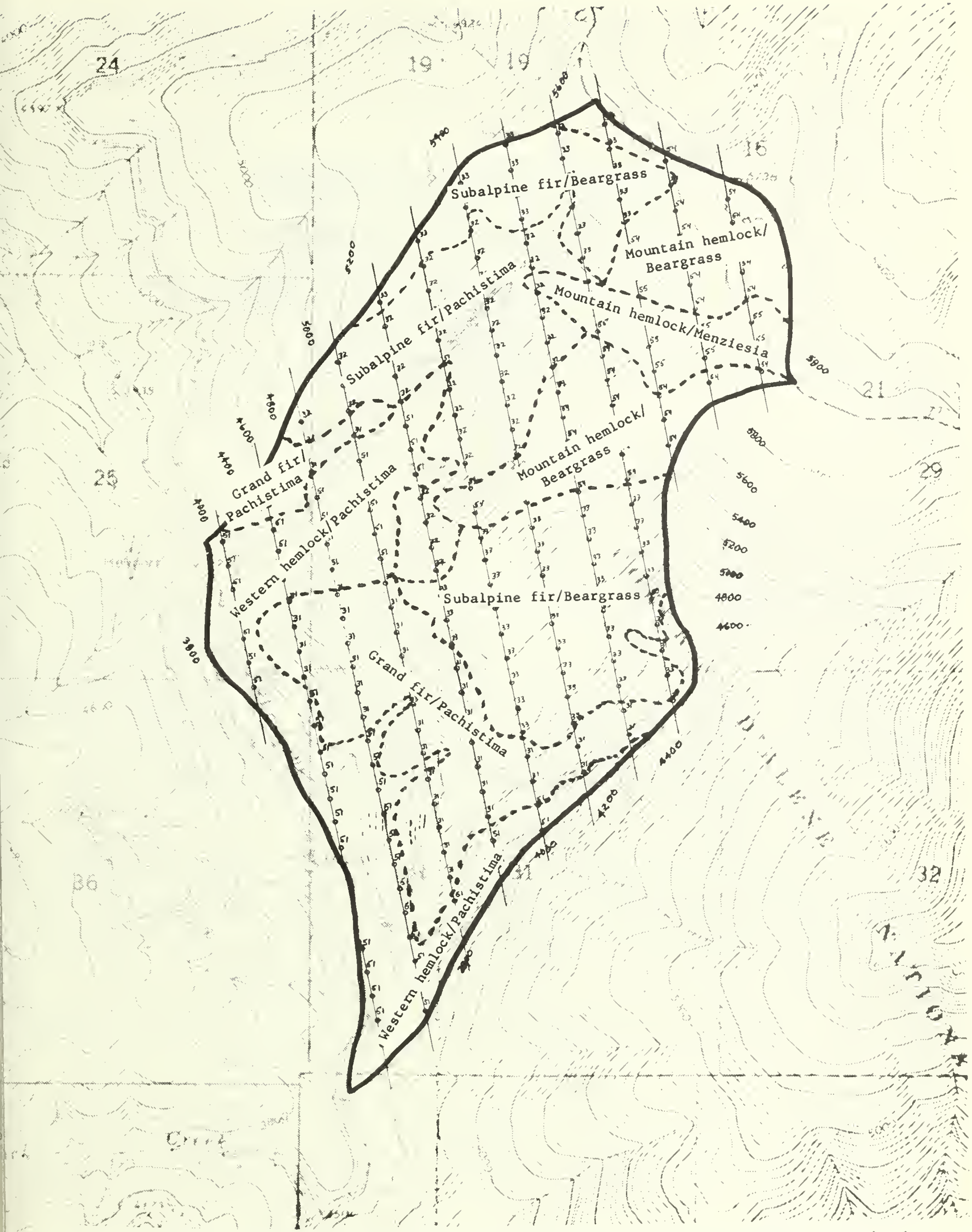

Figure 3.--Subcompartment map showing grid of sample points (each with numerical designation of habitat type) and the derived habitat type boundary lines.

HABITAT TYPES ENCOUNTERED

Total acreages of the principal habitat types, estimated from the final map by dot-grid count, were as follows:

Douglas-fir/ninebark	8,600
Grand fir/pachistima	198,200
Western hemlock/pachistima	374,700
Subalpine fir/pachistima	41,100
Subalpine fir/beargrass	15,900
Subalpine fir/menziesia	5,000
Mountain hemlock/beargrass	35,300
Mountain hemlock/menziesia	19,500
Lowland complexes	22,300
Total	720,600

The extensive representation of western hemlock and grand fir habitat types (more than 80 percent of the area) attests to the generally moderate environmental conditions within the Coeur d'Alene National Forest. Subalpine fir and mountain hemlock were climax on most of the remainder of the area (about 16 percent), not all of which was located at high elevations. The subalpine fir/pachistima habitat type also occurred in frost pocket situations on lower parts of many drainages.

The "lowland complexes" designation includes fairly level areas near lakes and rivers draining into swampy terrain and also includes most of the broad flats that border the lower ends of major mountain streams. Habitat types found in such places (western hemlock/pachistima, western redcedar/ladyfern, western redcedar/devil's-club, subalpine fir/pachistima, and riparian types) were lumped because changes from one to another occurred rapidly and were frequently associated with elevational differences that were too small to be determined on the available topographic maps.

Other habitat types exist on the Forest in isolated patches or stringers usually too small to map at the scale used (fig. 1). Among these, areas having ponderosa pine as the climax tree species were strictly confined to driest exposures at the lowest elevations. The Douglas-fir/pinegrass type was not mapped because its apparent occurrence was a result of repeated severe burns on limited areas of steep south slopes. These areas could not be delineated without field examination; also, there was question about the relative permanency of the retrograded condition in the absence of further wildfires. Western redcedar/pachistima was not differentiated from western hemlock/pachistima because information was not available as to environmental distinctions that could be used to map each of these types individually. The western redcedar/devil's-club and western redcedar/ladyfern types occurred only as very narrow stringers along stream margins at intermediate elevations. Two high-elevation types--subalpine fir/grouse whortleberry and whitebark pine/subalpine fir--rarely were encountered.

ENVIRONMENTAL INFLUENCES

We tentatively had planned to try to develop mathematically-expressed relationships between habitat type occurrence and topographic variables so that computer methods could be used to map the bulk of the National Forest. However, this approach was dropped, because of the complexity of analytical requirements and of time limitations. Instead, the environmental relationships that had been observed, together with those that had been reported by Daubenmire in 1943[1] and in 1968,[4] were used to develop general criteria for interpretive mapping.

Effects of Geographic Location

Differences in growing conditions on the Coeur d'Alene National Forest that are attributed to geographic location are most noticeable between the east and west portions. On the west side, precipitation is relatively low and evapotranspiration is relatively high on the exposed western slopes. This, coupled with the warm temperatures at the lowest elevations, produced the driest climatic conditions that we encountered. As the air masses move eastward, they are cooled as they pass over and beyond the first range of mountains; this causes increased precipitation and corresponding changes in the representation of habitat types. Toward the east side, there is a proportionately greater acreage of high-elevation habitat types because the mountain ranges are higher than those on the west.

Little more than half a degree of latitude separates the northernmost and southernmost extensions of the Forest, which is equivalent to less than 1 percent difference in total yearly energy input in terms of potential solar radiation. By itself, this difference does not appear to cause any significant shifts in the pattern of habitat type occurrence.

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[4] R. Daubenmire and Jean B. Daubenmire. Forest vegetation in eastern Washington and northern Idaho. Wash. Agric. Exp. Stn. Tech. Bull. 60, 104 p., illus. 1968.

Effects of Landform

Elevation, aspect, slope configuration, and adjacent land features are four of the major landform characteristics that exercise strong control over environmental conditions through complex interactions; in turn, the conditions are intimately related to plant distribution. Foremost among these conditions are precipitation, infiltration, evapotranspiration, growing season, soil depth, wind exposure, and cold air drainage.

Elevation

Daubenmire[1] reported that vegetation zones do not exist as rigidly-defined altitudinal belts in the Northern Rocky Mountains, but that the habitat types do bear a generally consistent altitudinal relationship to each other as a consequence of different temperature and moisture optima. How abruptly or how gradually the transition occurs between habitat types on the Coeur d'Alene National Forest (fig. 1) varies with the kind of topographic factor causing the change. On slopes where the factor was elevation rather than aspect or slope configuration, the ecotone was typically broad. Usually it appeared as a mosaic of the merging types in varying degrees of intermediacy. Such mosaics were most frequently encountered at the higher elevations in the ecotones among western hemlock, subalpine fir, and mountain hemlock habitat types.

Aspect

Overall, most of the changes in habitat type were triggered by changes in aspect between opposing sides of a ridge or of a ravine. Areas that faced in southerly to westerly directions were characterized by relatively high heat loads and by greater exposure to drying winds, as well as by the moisture deficiencies that were usually intensified by the occurrence of thinner and rockier soils.[5]

From the standpoint of aspect alone, south-southwest slopes appeared to be driest and conditions became progressively cooler and moister in either clockwise or counterclockwise directions around to the north-northeast. This relationship did not apply only to the aspect of the main slope, but also to internal fluctuations in aspect associated with minor draws--especially those that were sharply incised. As a result, southerly-facing main slopes typically displayed an interfingering of a "moist" habitat type, such as western hemlock, upward in the draws from near the bottom of the main drainage into an overlying drier habitat type, such as grand fir. However, on northerly exposures, internal aspect changes had much less effect and the range of moisture conditions often fell within the requirements of a single habitat type.

Land Configuration

Viewed in cross-section, the shape of the land surface within a given area can be classed as convex, uniform, or concave (fig. 4). Convex surfaces are represented chiefly by upper slopes and ridges. Southerly exposures at these locations on the Coeur d'Alene were markedly drier than those facing the north, so ecotones between habitat types customarily lay near the ridgelines. The ecotone was usually located a short distance over the ridge on the northerly side where moisture conditions became significantly improved. Sometimes, however, deeper soils that occurred in saddles or on broad ridgetops modified the effect of exposure, and then the zone of habitat type transition shifted toward the southerly side of the ridge.

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[5] Nedavia Bethlahmy. Water yield and annual peaks as affected by exposure in mountainous terrain. Intermt. For. & Range Exp. Stn. (Unpubl. manuscript.)

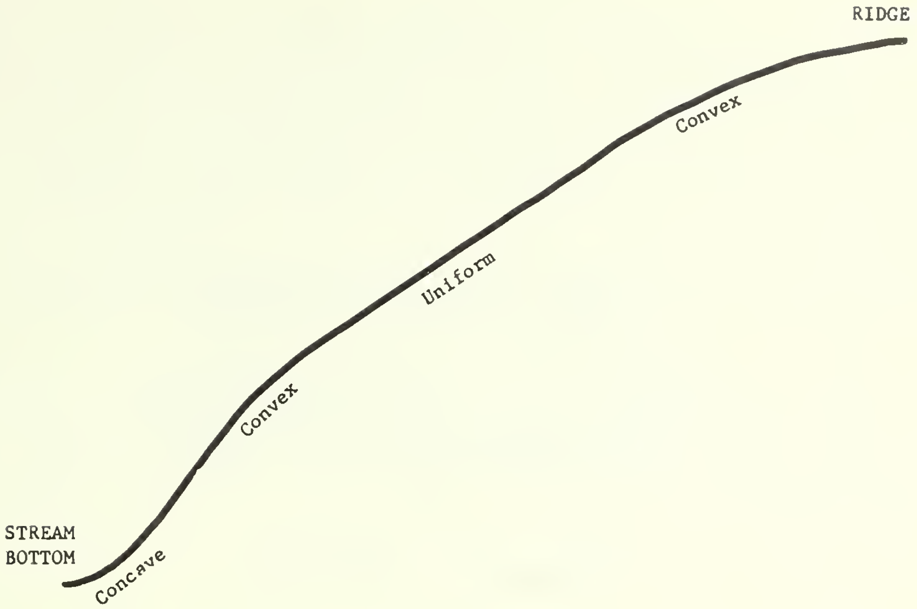

Figure 4.--Diagrammatic cross-section of a mountain slope showing a typical sequence of configuration classes. The same sequences also occur within the draws superimposed on main slopes.

Steeply convex conditions are likely to be especially dry because of greater erosion and consequent thin, rocky soils. Areas of this kind were relatively small, and they were typically encountered toward the lower part of a main slope where a rather abrupt break had been caused by geologically recent stream-cutting action. The local presence of a very dry habitat type was often associated with this configuration, especially on the brow of a southward-descending spur ridge.

The uniform class of configuration is found mainly on midslope positions where its extent is limited by subdrainage development. Changes in habitat type within this kind of area were infrequent and were usually caused by changes in elevation or soil type.

Concave landforms are associated with lower slopes, draws, benches, and stream bottoms. In comparison with the other two classes, the soils in such areas were moister and generally were accompanied by lower air temperatures and higher humidities that resulted from cold air drainage and less direct sunlight. As a consequence of these conditions and of their interactions with aspect, a habitat-type change commonly occurred on the lower portion of southerly slopes; for example, from western hemlock in a ravine to grand fir on the slope above. How far up from the bottom of the ravine that this would happen depended mainly on interrelated factors of aspect, slope configuration, and certain modifying effects of adjacent land features.

Although not considered in the mapping project because of the small size of areas involved, another change in habitat type occurred in concave topography where western redcedar/ladyfern and western redcedar/devil's-club were represented on streamside sites. These types were also limited for the most part to intermediate elevations and to the gentler gradients at lower ends of the drainages.

Adjacent Land Features

The most complex and difficult topographic variables to evaluate are those associated with adjacent land features. The features can range in scale from a neighboring mountain to a nearby spur ridge. Depending upon the size of the feature and distance from a given site, it can have a significant effect at that site on duration of direct sunlight, on wind and other air movement, and on precipitation patterns. For example, observations on the Coeur d'Alene National Forest showed that the ecotone between western hemlock/pachistima and grand fir/pachistima habitat types occurred at noticeably higher elevations on west-facing slopes if there was a high mountain or ridge on the other side of an intervening steep and relatively narrow drainage. The difference was caused by the greater sheltering influence of the adjacent mountain against drying winds from the west and by the early shading of the observed slopes from the afternoon sun.

Constrictions in valley width were responsible for more obvious examples of the effect of adjacent land features. In these locations, pooling of cold air draining from upper slopes created a frostpocket condition, which was accompanied by the appearance of subalpine fir/pachistima habitat type in the valley bottom and in lower portions of adjoining subdrainages for varying distances above the point of constriction.

Effects of Fire

About one-fourth of the Coeur d'Alene National Forest was burned over by the historic fires of 1910. Reburns and sheep grazing on some of these areas in subsequent years have caused the virtual disappearance of key plant species that would have indicated a moister habitat type than seems to be represented now. This inference was drawn from the observed patterns of habitat type occurrence on similarly situated areas in the vicinity that remained relatively undisturbed. Nearly all of the sites showing such incongruity in habitat type were located on steep south- or southwest-facing slopes where soil loss had been heavy. Many were at relatively high elevations where the present vegetation indicated the habitat type to be Douglas-fir/pinegrass.

Although there is some question whether or not the dry conditions presently manifested are permanent enough to warrant this distinction, it seems likely that the retrogressive influences of past disturbance have been so rigorous as to justify the lowered habitat type designation. However, this was not done in our mapping because specific information on site history and on soils throughout the National Forest was not available. Instead, all areas were mapped entirely on the basis of the broadly derived topographic relationships described in foregoing and subsequent sections.

PATTERN OF HABITAT TYPE OCCURRENCE

The main characteristics of habitat type occurrence on the Coeur d'Alene National Forest as they were inferred from inventory plots and limited supplementary reconnaissance are outlined below. The elevational boundaries given are generalized averages, subject to considerable local variation caused by other interacting environmental factors.

Douglas-fir/ninebark --This habitat type is most prevalent on the western side of the Forest where it occupies nearly all southerly-facing sites (southeast to west-northwest)[6] below about 2,400 feet in elevation. Above 2,400 feet, the type becomes increasingly restricted to the more southerly aspects and steeper slopes until at about 3,600 to 3,800 feet it is essentially limited to small rocky areas on the tops of spur ridges that descend steeply to the south. Eastward beyond the first range of mountains, the type occurs only on the latter kind of site.

Grand fir/pachistima.--Along the western front of the Forest, grand fir is climax up to about 2,400 feet on slopes facing northwest to southeast, as well as in drainages on all aspects. From 2,400 feet to about 3,800 feet, the grand fir type replaces Douglas-fir on southerly slopes; from there it extends upward to subalpine habitat types. Eastward from this first range of mountains, east-northeast to west-northwest aspects are generally grand fir type. Above 3,600 feet, however, the type becomes increasingly limited to slopes that face from south to west and that have thinner soils.

Western hemlock/pachistima.--The western hemlock habitat type is first encountered on the west side of the Forest as a narrow stringer in the bottoms of drainages at about

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[6] Inclusive compass directions are to be read clockwise.

2,400 feet--somewhat lower in drainages running in a northerly direction and somewhat higher in drainages running southerly. Western hemlock takes over from grand fir on due north-facing slopes at about the same elevation, gradually extending its coverage to the northwest and to the northeast as elevation increases. In the mountains to the east, on the other hand, the western hemlock type rapidly becomes predominant on all northerly slopes (west-northwest to east-southeast) up to subalpine habitats. The distance to which this type extends up the south-facing sides of drainages depends chiefly upon the protection from exposure provided by local features. In addition, western hemlock frequently fingers up ravines into higher elevations dominated by subalpine fir types.

Subalpine fir habitat types.--On the mountains to the west, the relatively small acreage wherein these habitat types are represented is mostly located in the northwest corner of the Forest at elevations above 4,800 feet. Ridges and upper south-to-west slopes are generally classified as subalpine fir/beargrass and slopes of other aspects are generally subalpine fir/pachistima. Proceeding eastward, the trend of elevational occurrence is lower; on the slopes of the Bitterroot Divide, subalpine fir often becomes climax at about 4,400 to 4,500 feet. The subalpine fir/beargrass type again predominates on ridges and dry southeast-to-west exposures on upper slopes. Subalpine fir/pachistima is represented in the draws of dissected southerly slopes, on adjacent southeast and northwest slopes, and, frequently, on all aspects in a rather narrow transitional zone between the beargrass and menziesia climax communities above and grand fir or western hemlock types below. The subalpine fir/menziesia habitat type seldom occurs below about 4,600 feet; it is quite restricted to moist and generally concave topography on north-to-east-facing slopes.

Mountain hemlock habitat types.--Representation of mountain hemlock habitat types is confined mainly to the eastern third of the Forest where they occur at high elevations above the subalpine fir types. Usually the transition to mountain hemlock takes place above 5,000 feet, but the hemlock occasionally replaces subalpine fir at elevations as low as 4,600 feet in northeast and southeast sections of the Forest; the cause for this was not apparent. The two mountain hemlock habitat types follow the same distributional pattern in relation to aspect and exposure as described for subalpine fir.

CONCLUSIONS

On the Coeur d'Alene National Forest, a low intensity of field sampling has given insight into relationships between habitat type and recognized topographic factors that appears good enough to have provided, in turn, a useful habitat type map and general key to vegetation potential of the entire Forest. The map should be regarded as a first approximation; hopefully, it will be corrected and amplified as specific areas are more closely examined during the course of ongoing management activities. Also, additional knowledge about such factors as precipitation patterns, geomorphology, and soils should help to make subsequent interpretive mapping more detailed and precise.

Accuracy of Mapping

Data limitations imposed by the inventory sampling design and inadequate supplementary reconnaissance were mainly responsible for certain shortcomings of the habitat type mapping on the Coeur d'Alene National Forest. Several factors materially affected mapping accuracy, specifically:

1. Some of the minor habitat types were ignored because the individual areas of occurrence were too small to have been adequately observed or to have been mapped at the scale used. Other habitat types were combined because good criteria for their separate identification were lacking. Instances of these kinds are given on page 6.

2. Some habitat types were more reliably identified than others by the field crews, and some ecotones were sharper and could be more readily associated with topographic variables than others. It is fortunate that grand fir and western hemlock were two of the best types in both respects, because together they constituted the climax vegetation on about 80 percent of the National Forest. High elevation types, on the other hand, were often less easily differentiated, their relationships to topographic changes were less clear, and their ecotones were relatively broad and complex.

3. Within the subcompartments selected for inventory sampling, the 5- or 10-chain distance between adjacent plots that differed in habitat type designations frequently left considerable room for speculation about the actual location of the intervening ecotone on the subcompartment map. Errors that may have resulted probably would have been carried over by extrapolative mapping into adjoining parts of the Forest.

4. Extrapolation of habitat type and topographic relationships became less reliable as distances from inventoried subcompartments and reconnoitered points increased.

5. As Daubenmire has reported,[7] cartographic errors in the topographic base map can occur rather frequently on rough forested terrain. Inaccurate road locations are particularly serious because the roads frequently provide key features for on-the-ground orientation. Other base-map faults involve minor breaks or changes in slope direction that the cartographer ignored or could not detect on aerial photographs because of tall tree cover. These omitted features may sometimes be associated with important ecotones, in which case their absence from the map will cause corresponding inaccuracies in the delineation of habitat types within those areas.

Recommended Changes in Mapping Procedures

It has been pointed out that the procedure followed for collecting habitat type information on this National Forest developed as an integral part of the scheduled timber inventory operation. Under other circumstances and in retrospect, it would have been more efficient to employ perhaps two or three professionals well trained in the local ecology to work together for a field season exclusively on mapping of habitat types. Rather than classifying the type at mechanically spaced points within certain sample units, they should first attempt through general reconnaissance to determine the pattern of habitat type occurrence throughout the Forest and to identify the environmental characteristics that might be usefully related. This information would indicate which habitat types were apt to be most difficult to delineate. It would also provide guidance for subsequent allocation of reconnaissance effort that would be more specifically directed toward tracing the actual course of the ecotones in typical situations and toward developing more definitive criteria for interpretive mapping.

In many other parts of the Northern Rocky Mountains, habitat type mapping of forest land promises to be more difficult than it was in the Coeur d'Alene National Forest. Not only did the Coeur d'Alene have an unusually good network of roads available for reconnaissance, but the degree of diversity in climate, soils, and topography was comparatively moderate. More variable conditions, such as are being encountered in western Montana,[8] will increase the number and distributional complexity of habitat types, making the need for competent personnel and detailed reconnaissance even more imperative.

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[7] R. Daubenmire. A comparison of approaches to the mapping of forest land for intensive management. For. Chron. 48(2):87-91, illus. 1973.

[8] Personal communication with Robert D. Pfister, Forest Ecologist, Intermt. For. & Range Exp. Stn., stationed at the Forestry Sciences Laboratory in Missoula, Montana.

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Grand fir/pachistima habitat type as represented on a mid-elevation ridgetop site.

Photo on back cover shows western hemlock/pachistima habitat type as represented on a lower north-facing slope.

PONDEROSA PINE BIBLIOGRAPHY II. 1966-1970

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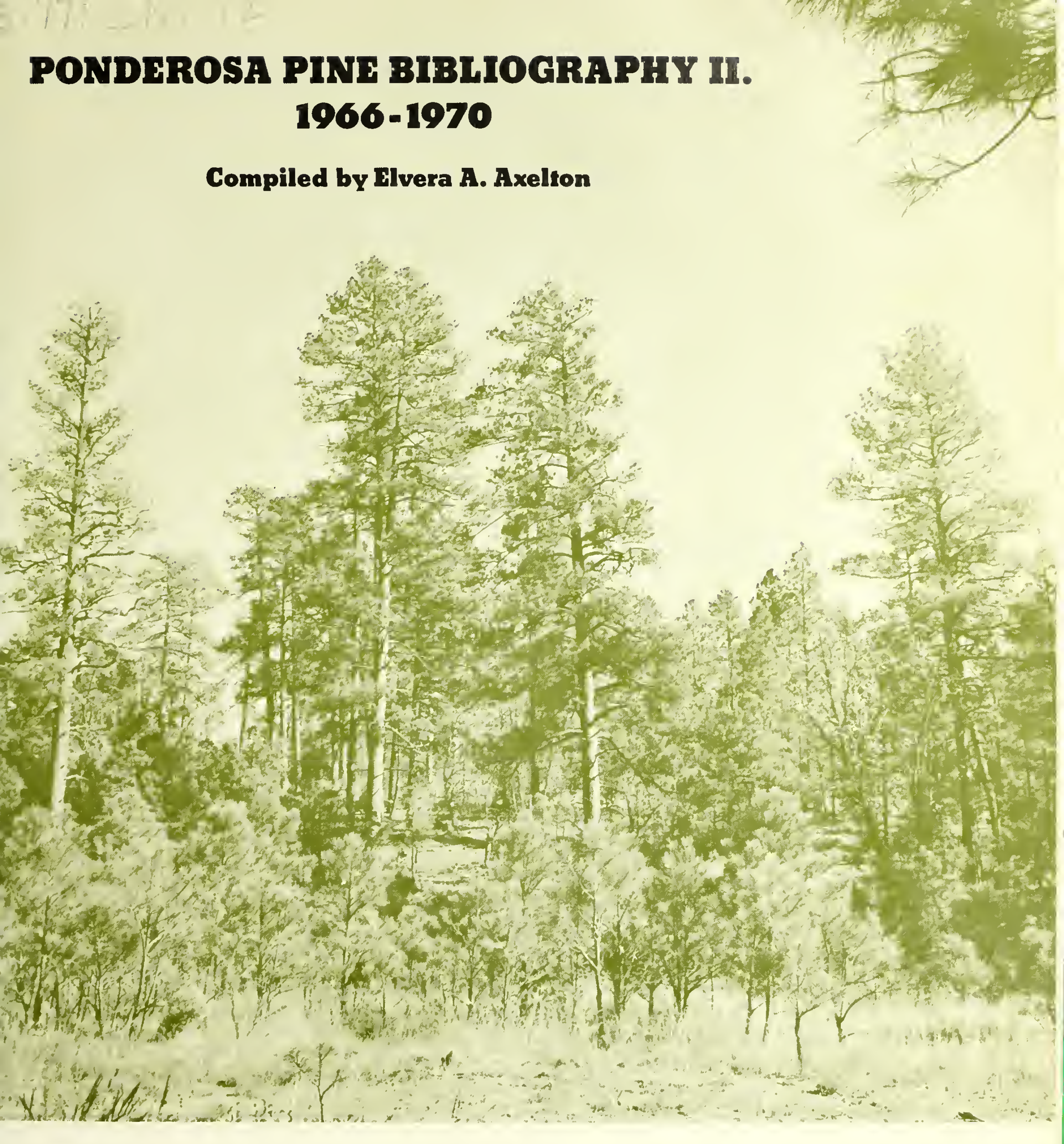

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CONTENTS

Page

FOREWORD iv

BIBLIOGRAPHY 1

INDEX 55

OTHER KNOWN REFERENCES 59

ABSTRACT

This bibliography of Pinus ponderosa Laws. updates through 1970, "Ponderosa pine bibliography through 1965" by Elvera A. Axelton, 1967, USDA Forest Service Research Paper INT-40, 150 pages, illus. A subject index is supplied.

KEYWORDS: ponderosa pine, bibliography

FOREWORD

Ponderosa pine (Pinus ponderosa Laws.) is one of the most important softwood species in the United States. Because of its extensive range and economic importance, considerable research has been conducted on this valuable species. The published results of these research efforts provide an impressive number of references. Roe and Boe[1] compiled the initial bibliography with references through 1949. This Supplement updates through 1970 the bibliography by Axelton (25) and was compiled at the Boise project headquarters of the Intermountain Forest and Range Experiment Station.

References have been limited to published material. A partial listing of theses and citations of published abstracts of papers are shown separately on pages 59-63, but are not included in the Index. A few foreign publications have been included, although a search of foreign literature was not made. Popular-type articles have been omitted.

The subject index follows the Oxford System of classification for forestry, except in a few cases where the index was slightly modified to simplify the presentation of subject matter. Articles were indexed under what was considered the principal topic, but no reference was listed under more than three subjects. Material pertaining to forest pests, although dealing with both damage and control, was indexed under "Damage." Only articles dealing primarily with control were indexed under "Protection."

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[1] Arthur L. Roe and Kenneth N. Boe. Ponderosa pine bibliography. U.S. Forest Service, Northern Rocky Mountain Forest and Range Experiment Station Paper 22, 74 p., 1950.

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INDEX

SITE FACTORS

CLIMATE - 22, 87, 222, 223, 450

SOIL SCIENCE
- Physics - 134, 136, 231, 283
- Chemistry - 215
- Formation - 6, 8, 65, 133, 199, 334, 711
- Classification - 691
- Fertility - 100, 124, 463
- Biology - 77, 371, 704
- Surveys - 368, 622

HYDROLOGY, WATERSHED MANAGEMENT
- Interception, Logging, Erosion, etc. - 54, 58, 82, 84, 122, 141, 169, 200, 241, 259, 283, 286, 322, 424, 461, 473, 474, 517, 538, 556, 640, 712, 731

WILDLIFE MANAGEMENT

HABITAT
- Mammals, General - 154, 170, 299, 386, 402, 476, 480, 513-516, 570, 571, 650, 720
- Birds - 26, 69, 596
- Fish - 556

BOTANY

PLANT CHEMISTRY - 116, 275, 519, 540, 555, 577, 581-583, 599, 724

PLANT PHYSIOLOGY
- General - 5, 162, 271, 723
- Transpiration - 157, 366, 520
- Photosynthesis - 234, 496, 497
- Physiology of Growth and Development - 305, 331, 722

PLANT MORPHOLOGY - 101, 240, 367, 396, 545, 634, 672

PLANT GENETICS
- Heredity, Breeding and Variation - 96, 115, 148, 149, 151, 197, 240, 345, 575-579, 585, 607, 627, 662, 669, 671
- Taxonomic Aspects of Hybrids - 471, 545, 581

HISTOLOGY - 246

TAXONOMY - 147, 149, 360, 431, 471

PLANT ECOLOGY

SILVICAL CHARACTERISTICS - 328, 510
- Distribution - 78, 150, 152, 290, 360, 405, 450, 471, 639
- Atmospheric Relations
  - Light Relations - 22, 354, 512, 643
  - Temperature Relations - 125, 134, 136, 346, 354, 497
- Water, Soil and Root Relations
  - Water Relations - 125, 157, 164, 222, 223, 231, 361, 366, 469, 494, 495, 520
  - Soil Nutrient and Chemical Soil Relations - 133, 180, 217, 334, 361, 463, 622, 692, 725-727
  - Special Modes of Nutrition - 229, 244, 410, 411, 523, 706
  - Root Relations, Root Development, etc. - 59, 279, 282, 333, 362, 385, 452, 616-619, 722
- Reaction to Biotic Influences & Fire
  - Plant Competition - 40, 305, 348, 362, 433, 454, 725-727
  - Influence of Animals - 64, 574, 687
  - Influence of Fire - 62, 90, 441, 678-680
- Reproductive Behavior
  - Flowering and pollination - 331, 592
  - Seed Dispersal - 36, 232, 687
  - Germination and Seedling Development - 116, 347, 350, 355

- Life Form, Habit
  - Growth as influenced by environment - 138, 653
- Phenology - 59, 340

SYNECOLOGY, PLANT SOCIOLOGY
- Palaeoecology, History of Vegetation, Pollen Analysis - 24, 285, 676, 682
- Succession, Alternation and Periodicity of Vegetation - 63, 90, 163, 688, 715
- Units of Vegetation, Ecosystems, Communities, etc. - 180, 273, 408
- Layer Communities - 64, 120-123, 170, 199, 304, 386, 433, 515, 516, 720, 721
- Synecological Measurements and Methods - 686
- Vegetation Types - 78, 163, 165, 166, 211, 231-233, 273, 290, 308, 310, 399, 453, 475, 510, 622, 673, 689, 692

SILVICULTURE

SILVICULTURAL SYSTEMS, CONSTITUTION AND COMPOSITION OF STANDS
- High Forest Systems - 21, 390, 461
- Constitution and Composition of Stands, Forms of Stands - 103, 161, 165, 200, 447, 458

REGENERATION AND FORMATION OF STANDS
- Regeneration, General - 3, 280, 552, 681
- Natural Regeneration - 64, 90, 93, 169, 390, 392, 504, 564, 604
- Artificial Regeneration
  - General - 389, 553
  - Choice and Trial of Species, Races, etc. - 18, 91, 115, 145, 146, 159, 190, 192, 232, 292, 315, 336, 340, 345, 346, 372, 410, 419, 420, 482, 511, 562, 563, 566, 591, 607, 615, 698, 714, 715
  - Preparatory Work
    - Pretreatment and Preparation of Site - 52, 230, 237, 238, 260, 262, 263, 362, 389
- Seed, Nursery Practice, Direct Sowing
  - Seed Production (seed years, seed crops, etc.) - 33, 185, 186, 207, 349, 390, 654, 671
- Seed Collection - 88
  - Seed Storage and Treatment - 189, 264, 486, 528
  - Seed Testing, Germination tests, Viability, Seed Quality - 32, 245, 265, 347, 350, 605
- Plant Rearing, Nursery Practices
  - Nursery Sites - 387
  - Preparation and Treatment of Soil, including fertilizers, etc. - 134, 242, 352, 387, 485, 675, 719
  - Sowing and Covering - 188, 512
  - Transplanting and Lining Out - 333, 616-619
  - Watering and Irrigation - 277
  - Pruning - 341
  - Protection Measures in Nurseries - 485
  - Vegetative Propagation - 302
  - Greenhouses, Raising in Pots, tubes, etc. - 278, 642, 645
- Formation of Stands by Direct Sowing - 34, 93, 135, 235, 237, 277, 363, 389, 432, 605, 606
- Planting Stock
  - Kind of Stock, Handling and Treatment - 4, 70, 82, 238, 301, 520, 554
- Methods of Planting, Fertilizers, etc. - 41, 276, 279, 307, 364, 371
- Afforestation - 103, 224, 232, 389
- Underplanting, Advance Planting, etc. - 725-727
- Care of Regeneration or Plantations - 227, 451
- Amelioration of Forest Sites - 7, 217, 297, 629, 666, 705

TENDING OF STANDS AND TREES
- Thinnings - 7, 18, 38-40, 71, 121, 153, 161, 171, 172, 195, 201, 203, 208, 386, 388, 440, 456, 461, 653, 666, 678-680
- Opening of Canopy, Release, etc. - 456, 655, 656
- Pruning - 37
- Control of Undesirable Undergrowth, etc. - 40, 52, 539, 635

SHELTERBELTS, WINDBREAKS - 216, 655, 656

RANGE MANAGEMENT - 120, 121, 123, 158, 169, 257, 258, 284, 334, 352, 386, 394, 402, 406, 473, 480, 481, 514-516, 570, 571, 573, 590, 621

ARBORICULTURE - 168, 621, 720, 721

HARVESTING OF WOOD, LOGGING AND TRANSPORT

DEGREE OF UTILIZATION AND WASTE - 175

CLEARING THE FELLING SITE - 171, 172, 236, 547, 626, 651

TOOLS, EQUIPMENT FOR FELLING, TRANSPORT, ETC. - 35, 295

FOREST INJURIES AND PROTECTION

GENERAL FOREST PROTECTION
- Natural and Biological Control - 575-579, 613
- Silvicultural Control - 261, 358
- Chemical Control - 52, 194, 539, 587

INJURIES FOR INORGANIC AGENCIES (Excluding Fire)
- Air Currents - 313
- Temperature Influences - 497
- Snow Damage - 458, 508
- Soil Conditions, Erosion Effects - 281, 470, 594, 595
- Chemical Influences (Atmospheric) - 94, 97, 129, 131, 132, 254, 267, 274, 317, 342, 426-429, 470, 518, 600, 603, 683, 684
- Electrical and Cosmic Influences - 312, 313, 519, 551, 631-633

FOREST FIRES
- Causes, Fire Danger and Behavior, Prevention and Control - 6, 12-15, 61, 85, 86, 144, 153, 171, 172, 195, 209, 210, 226, 439-441, 498, 537, 632, 633, 697, 702, 703
- Beneficial Effects and Uses of Fire - 62, 169, 226, 236, 678-680

DAMAGE BY HARMFUL PLANTS AND DISEASES
- Forest Weeds - 2, 230, 373, 451, 590, 638
- Parasitic Plants - 44, 112, 114, 204, 205, 228, 247-253, 261, 343, 358, 460, 535, 536, 546, 574, 613, 640, 693, 694, 696
- Diseases - 11, 48, 49, 60, 74, 92, 109-111, 113, 119, 126-128, 130, 167, 177, 178, 194, 213, 218-221, 225, 287-289, 329, 353, 357, 369, 371, 404, 422, 423, 425, 468, 483, 484, 487-493, 502, 509, 560, 561, 586, 587, 600, 609, 644, 657, 665, 668, 710, 728-730, 732

DAMAGE BY ANIMALS
- Mammals - 31, 34, 66, 67, 154, 155, 174, 230, 293, 294, 296, 349, 477, 513, 572, 620
- Birds - 455, 457
- Insects
  - Coleoptera - 45-47, 55-57, 74-76, 89, 95, 98, 105-108, 131, 132, 140, 142, 143, 181-183, 266, 306, 312, 314, 318, 323, 337-339, 374, 375, 377-384, 401, 415-418, 427, 462, 464, 499, 500, 505, 543, 544, 548, 549, 551, 567-569, 575-580, 583, 584, 600, 603, 608, 611, 614, 623, 625, 630, 659-661, 707-709, 713, 716, 724
  - Lepidoptera - 99, 101, 102, 139, 176, 196, 255, 256, 376, 395, 413, 430, 442, 443, 501, 503, 506, 532, 534, 565, 610, 612, 699
  - Other and General - 42, 97, 160, 193, 202, 268-270, 300, 313, 319, 321, 324, 332, 335, 523-527, 548, 550, 601, 602, 624, 658, 667, 677, 685, 695, 701

FOREST MENSURATION

STEM MEASUREMENTS
- Diameter - 43, 507
- Height - 445
- Bark - 81, 330

VOLUME OF TREES AND STANDS - 309, 326, 327, 359

SURVEYS - 19, 120, 124, 309, 478

VOLUME BY ASSORTMENTS, MERCHANTABLE VOLUME - 29, 30, 198

LOG MEASUREMENT, "SCALING" - 652, 717, 718

SPECIAL MEASUREMENTS OF TREES AND STANDS
- Quantity and Area of Foliage - 367
- Crown Density - 479
- Density of Stocking - 344, 447

ASSESSMENT OF SITE QUALITY - 80, 100, 124, 622, 674

INCREMENT, DEVELOPMENT AND STRUCTURE OF STANDS
- Increment in Height, Diameter, Basal Area - 138, 145, 184, 212, 222, 223, 282, 351, 394, 446, 653
- Volume Increment, Mortality and Thinnings - 71, 666
- Yield Tables - 444, 449

SURVEYING AND MAPPING
- Aerial Survey - 23, 266-270, 342, 368, 677, 683-685

FOREST MANAGEMENT AND ECONOMICS OF FORESTRY

FOREST MANAGEMENT - 159, 239, 446, 448, 459, 538, 647-649,

ECONOMICS - 20, 174, 203-206, 358, 389, 409, 439, 635-637

COSTS OF LOGGING OPERATIONS - 21, 236, 237, 391, 393

MARKETING OF FOREST PRODUCTS AND ECONOMICS OF WOOD INDUSTRIES

MARKETING OF FOREST PRODUCTS, GENERAL - 1, 243

DEMAND AND SUPPLY - 214, 397, 398

ECONOMICS OF FOREST PRODUCTS INDUSTRIES
  General - 118, 214, 365, 700
  Output of Forest Products Industries - 72, 558

FOREST PRODUCTS AND THEIR UTILIZATION

WOOD AND BARK STRUCTURE AND PROPERTIES
  General - 16, 435
  Structure, Identification - 27, 351, 597, 598, 664

PHYSICAL AND MECHANICAL PROPERTIES
  General - 18, 191, 210, 370
  Density, Gravity, Buoyancy - 184, 646, 663
  Strength Properties - 303, 311, 356

WOOD CHEMISTRY
  Organic constituents - 10, 522, 531, 541, 542, 577, 579, 581-583, 585, 724
  Chemical Effects of Heat - 79, 628

EFFECT OF GROWTH FACTORS ON STRUCTURE AND PROPERTIES - 137, 297, 298

FINISHING OF WOOD - 173, 436

MANUFACTURING INDUSTRIES AND PRODUCTS
  General - 175, 558
  Veneer and Plywood - 28, 407, 438
  Timber in Buildings - 51

WOOD PRESERVATION, DAMAGE, AND SEASONING
  Wood Preservation - 50, 68, 179, 554, 588, 690
  Treatments to Improve Resistance of Wood to Damaging Agencies - 320
  Fireproofing - 79
  Attack by Plant Organisms, Fungi, etc. - 272, 421, 434, 472, 529, 559
  Attack by Animals - 533, 589
  Seasoning, Drying - 9, 210, 325, 400, 521

GRADING OF WOOD AND WOOD PRODUCTS
  Detection of Injuries and Defects - 104, 198, 357
  Grading of Wood in the Rough - 28-30, 437

PULP INDUSTRIES, CHEMICAL UTILIZATION OF WOOD
  Pulp and Paper Manufacture - 530
  Composite Materials - 83
  Utilization of Wood Extractives - 291, 316

OTHER MINOR FOREST PRODUCTS
  Bark Products - 73, 242, 414, 719
  Resin and Turpentine - 641

GENERAL FORESTRY AND SOCIAL ECONOMICS OF FORESTRY

FOREST STATISTICS AND RESOURCES - 53, 117, 119, 465, 466, 593, 700

BIBLIOGRAPHIES - 25, 156

INDIRECT SIGNIFICANCE OF FORESTS
  National Parks, Protected Areas, etc. - 17
  Recreation - 403, 467

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INVENTORY OF SLASH FUELS USING 3P SUBSAMPLING

William R. Beaufait,
Michael A. Marsden, and
Rodney A. Norum

USDA Forest Service General Technical Report INT-13, 1974
INTERMOUNTAIN FOREST & RANGE
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ACKNOWLEDGMENTS

The authors wish to recognize the advice and support given by Dr. A. R. Stage on application of 3P methods to fuel inventory, and the dedicated services of R. A. McCluskey, computer programer, both at the Forestry Sciences Laboratory, Moscow. Their services are deeply appreciated.

USDA Forest Service
General Technical Report INT-13
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CONTENTS

Page

INTRODUCTION 1
    The System in Brief 1
    The Problem 2
    Literature Review 3

INVENTORY DESIGN 4
    Layout of Sampling Areas 4
    Fuel Size Classes 4
    Collateral Measurements and Computations 8

FIELD INVENTORY PROCEDURES 10
    Field Equipment and Supplies 10
    Laying Out the Grid 11
    Sampling a Point 11

FIELD DATA RECORDING SYSTEM 13

REDUCTION OF DATA 14
    Preparation of Auxiliary Data 14
    Data Processing Computer Programs 15

INVENTORY RESULTS 16

LITERATURE CITED 17

ABSTRACT

A recent large-scale study of prescribed broadcast burning in western Montana required the development of a system for inventory of clearcut logging slash fuels before and after fire treatment. The system is best suited for inventorying material which tends to be oriented parallel to the ground. The inventory system uses line intercept counts to compute fuel volume, weight, and surface area. 3P subsampling is used to inventory twigs (0-1 cm diameter). Data reduction was accomplished with specially written computer programs. When used with proper and sufficient subsampling for auxiliary, collateral data, the system is well suited for the inventory of slash fuels in many forest types.

OXFORD: 432:432.16. KEYWORDS: fire control, slash disposal (fuel reduction), fuel inventory, 3P subsampling, planar intercept sampling.

INTRODUCTION

A large-scale study of prescribed burning conducted in the larch--Douglas-fir type (SAF type 212:Society of American Foresters 1967, p. 46) in western Montana required the development of a system to inventory clearcut logging slash fuels both before and after treatment by broadcast fires of varying intensity. This paper describes the theory, sampling design, field procedures, and data processing programs that were developed for the inventory system applied on one hundred 2 1/2-acre plots. Plots were located on the four cardinal exposures and on slopes ranging from 10 to 70 percent to offer wide range of fuel loading. The experience gained in the installation and measurement of the approximately 7,000 sampling points involved in this study should be of value to others who may wish to quantify similar slash fuels.

The System in Brief

Basically, this system is best suited for inventorying materials, such as logging slash or windthrown stands, that tend to be oriented parallel with the ground. The method of inventory is a variation on the line transect technique of sampling. The theory of line-transect measurements views intercepted, horizontal fuel particles as representative of the total mat of fuel.

Determination of the proper level of sampling and subsampling intensity is achieved through the same techniques used in such other mensurational problems as timber cruising. On our experimental 2 1/2-acre plots, we found that 66 transects, each 1 m long, adequately represented slash components less than 10 cm in diameter. However, this sampling intensity may not be suitable at other locations or for other sampling objectives.

The system requires that certain basic information about fuel categories be determined. One such item is the mean diameter of particles in a size class for a given fuel. The necessary mean diameters for this study were generated by a procedure described later. In other timber types it will be necessary to generate mean diameters of fuel particles within each size class for each additional species of tree.

In the 3P subsampling system, line intercept counts are used to compute fuel volume, weight, and surface area. If duff (the partially decayed organic matter on the forest floor) weight per unit of ground area is desired, a duff weight per unit of volume (bulk density) relationship must be developed as outlined later in this text. Duff bulk density varies from stand to stand and even between exposures. When proper and sufficient subsampling for needed mean diameters and duff bulk density are used, slash fuels in many forest types can be described by the system outlined in this paper.

The Problem

Our purpose for inventorying the organic debris on logged sites was to assess the influence of fuel quantities on the energy released during prescribed broadcast fires. The rate of energy released from a given area of a fire is often called the fire intensity, and the size and geometry of fuel particles have an influence on it. Tree species differ in their branching habit, branch size, and leaf morphology, thus yielding various ranges of fuel sizes and loadings. Due to its matlike physical form, duff may also be a fuel that influences fire intensity. Because of the complex variations in fuel bed structure and composition, a simple expression of total fuel weight per unit area is not sufficient to describe the energy released from a prescribed fire.

Logging slash consists of the tops, limbs, and leaves of harvested trees. In addition, there are whole cull trees and logs, noncommercial trees which are felled during the harvest operation, and the existing organic forest floor. The forest floor has a highly irregular interface with the mineral soil accentuated by partially buried logs, decayed stumps, and protruding rocks.

Some of the more important factors which combine to complicate the fuel bed on any given clearcut site are:

1. Steep slopes may influence the orientation and distribution of fallen fuels.

2. Changes in exposure, even within short distances, may have a profound effect on site productivity, thus resulting in variations in fuels.

3. Trees can be felled so that all tops are parallel and lying on the contour, or they may be felled in a random fashion.

4. Skid trails may be tractor width, scraped to bare mineral soil; or they may be narrow, multiple strips characteristic of cable skidding. They can alter fuel distribution considerably.

5. Tree-length skidding often results in disproportionate accumulations of treetops and limbs directly beneath jammer or high-lead settings, or in rows between a network of skid trails.

6. Utilization standards profoundly influence the amount of larger fuel particles left on a site.

Thus, a sufficiently definitive inventory was needed to allow statistical comparisons between various fuel complexes and resulting fire characteristics, responses, and effects.

Literature Review

Recent measurements of logging slash characteristics in the interior Douglas-fir forest type employed destructive sampling methods (Steele and Beaufait 1969). Data collected from forty 2-m-long transects revealed that:

1. Particles larger than 10 cm diameter are rarely consumed by broadcast fires.

2. High internal variation in slash fuel loading dictates the need for many measurement points within a fuel bed to reduce errors of estimate.

3. Destructive sampling, at the density required by the internal variability, results in alteration of the experimental material, and is uneconomical on large-scale studies.

4. Nondestructive sampling of logging slash using vertical planar transects is precise enough to provide inputs for fire intensity comparisons.

5. Short transects are easier to tally accurately than are long transects.

Warren and Olsen (1964) applied long-line transect procedures to an inventory of logging slash in New Zealand. Their study pointed out the importance of particle orientation with reference to the transect line. In 1967, Beaufait[2] outlined a method for describing all slash and duff components through a series of randomly oriented, 1-m-long vertical planes. VanWagner (1969) derived an equation useful in inventory of randomly-oriented slash particles. Brown (1971) expanded the mathematical model to accept a wide range of fuel conditions having particles of several shapes intersecting the sampling plane at all possible angles.

Slash sampling is painstaking and time-consuming work. Sound statistical procedures and efficient subsampling are required to reduce the costs of inventory. Counting up to 1,000 particles on each of thousands of transects is not economically feasible. The system described in this paper substitutes a combination of estimates and counts corresponding to Grosenbaugh's (1965) 3P subsampling procedures. A description of the method and our refinements is given later.

Likewise, it is impractical to count tree needles and components of the forest floor on a large number of transects. Fahnestock (1960) and Chandler (1960) published tables of needle weight for many western conifers. We emulated Brown's (1965) work with red and jack pine by subsampling needle-weight to branch-weight ratios, handling each species separately. Equations for calculating volume and surface area of needles per unit of branchwood were published by Brown (1970).

Duff is best characterized by an empirical relationship between duff depth and duff weight. Weight per unit of volume, or gross bulk density, can thereby be computed.

---

[2] William R. Beaufait. Prescribed fire cooperative study--Region 1-INT. Study Plan No. FS-INT-2102-12, on file at the Northern Forest Fire Laboratory, Intermountain Forest and Range Experiment Station, Missoula, Mont. 1967.

INVENTORY DESIGN

Layout of Sampling Areas

Three blocks of study units--Coram, Miller Creek, and Newman Ridge--were sampled during development of the inventory system. The sampling points were distributed mechanically over each of the experimental burning units. Figure 1 illustrates the three sampling patterns. At Coram, sampling points were placed at the intersections of a 1-chain grid superimposed on a 25-acre unit of slash. X and Y base lines of the grid were located at random. Each sampling point was designated by its X and Y values. The square grid layouts used at Miller Creek and Newman Ridge proved to be superior from a practical standpoint in the field.

At our second study block, Miller Creek, we chose to sample intensively the fuels in a central 2 1/2-acre plot within each 10-acre unit, leaving the border area as an isolation strip. On each of the first five units, 231 points were sampled. Analyses of these five units indicated that sample size on the remaining 55 units of this study could be reduced to 66 points without significant loss in precision. The subsampling ratio for sampling the twigs (<1 cm diameter) was determined from analysis of these first five units. At Newman Ridge three 2 1/2-acre plots, each having 66 sample points, were installed in each of the large units (fig. 1). Again, the required number of points may be different at other locations or for other objectives.

Fuel Size Classes

Western coniferous slash fuels may be conveniently grouped into five classes of different physical characteristics:

1. *Leaves (needles)*, suspended above the forest floor

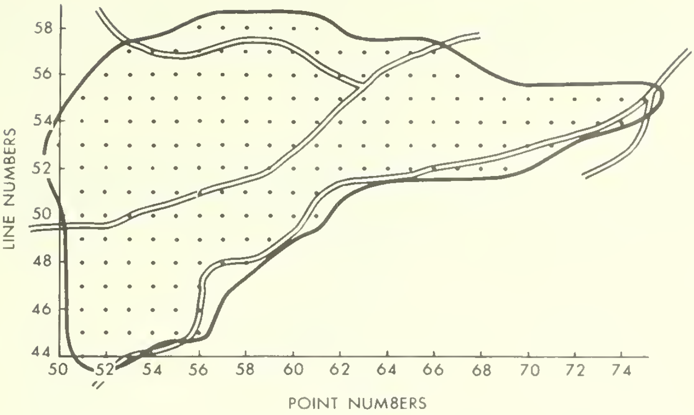
2. *Duff* (the partially decayed organic material in the F and H layers of the forest floor)

3. *Twigs*, woody particles (<1 cm diameter)

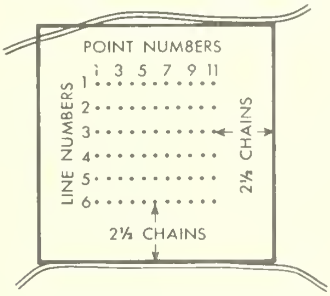
4. *Branches*, woody particles (1-10 cm diameter)

5. *Stems*, the tops of trees, or cull logs (>10 cm diameter)

CORAM BLOCK



TYPICAL UNIT FROM
MILLER CREEK BLOCK



TYPICAL UNITS FROM
NEWMAN RIDGE BLOCK

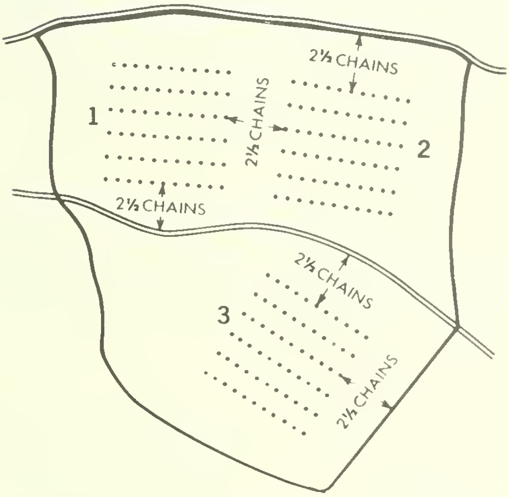


Figure 1.--Three slash fuel sampling patterns. Each has advantages, depending on inventory objectives.

Diameter is always measured at the point of intercept by a sampling plane as shown in figure 2. Material less than 10 cm in diameter occurring as central stems of brush or small trees was grouped, depending on its diameter, with twigs or branches. Fuels larger than 10 cm in diameter were further grouped into classes which are multiples of 10 cm (i.e., 11-20, 21-30, ...81-90 cm).

We gave emphasis to the distribution of needle-bearing twigs because fire spread and intensity in broadcast fires are largely dependent upon the quantity of small diameter fuel particles present. This approach required tolerance of relatively large errors in the numbers of large stems because fuels greater than 10 cm in diameter are rarely as well distributed as are fine fuels. The same is true, to a lesser degree, for fuels between 1 and 10 cm diameter.

The following sections deal with special features of sampling the five previously described fuel classes.

Sampling leaves (needles).--Needle volume, weight, and surface area are important measures of fuel loading. They are most easily expressed as functions of the number of leaf-bearing woody intercepts <1 cm in diameter. To this end we collected 25 twigs of each species from random locations in slash on all exposures. Sample twigs were clipped at their junction with branches or stems larger than 1 cm. If the twig tapered into a larger particle, only that portion less than 1 cm was included in the sample.

All samples were ovendried at 105°C, and then the needles were stripped off. The woody twigs and needles from each sample were weighed separately. One hundred randomly selected, ovendried needles from each sample were then counted out and weighed. From those data, we calculated a needle-to-branch weight ratio for each species, and the average weight per needle. Measurements of specific gravity and volume provided for subsequent conversions of weight to volume and surface area for all needles on the sampled area.

Sampling duff.--Duff is both a major source of fuel and the object of fire treatment. Duff depth and bulk density are important parameters that vary with slope, site quality, and exposure.

Using a cylindrical steel soil sampler we collected 12.7-cm (5-inch) diameter duff cores at 25 random locations on each of four exposures at both Miller Creek and Newman Ridge; and we measured the depth to mineral soil (to the nearest 0.5 cm) along opposing sides of the hole created by the soil sampler. The duff cores were ovendried to a constant weight at 105°C to provide data necessary in calculating bulk density and depth/weight ratios for each sample. The weight of incorporated mineral matter was subtracted from the total dry weight after burning each sample at 600°C and weighing the mineral residue to arrive at total organic content.

Regressions of duff weight on depth were developed for each cardinal exposure on each experimental block. The regression equations were sufficiently different to warrant stratification of duff data by exposure. These equations are specific to the blocks sampled for this study and may not apply to duff from other locations. Subsequently, the duff depth was sampled in the field, and duff weight per unit of area was computed by using the depth-weight regression equation that applied.

Sampling twigs (<1 cm).--The sampling of woody material less than 1 cm in diameter (twigs) consists of two phases: First, the number of particles intercepted by a 1-m-long vertical plane is estimated at all of the sample points on a unit. Second, fuel particles are actually counted on a randomly selected subsample of these points. The probability that a sample point will be chosen for counting is made proportional to the number of twigs estimated at that point (Cochran 1963).

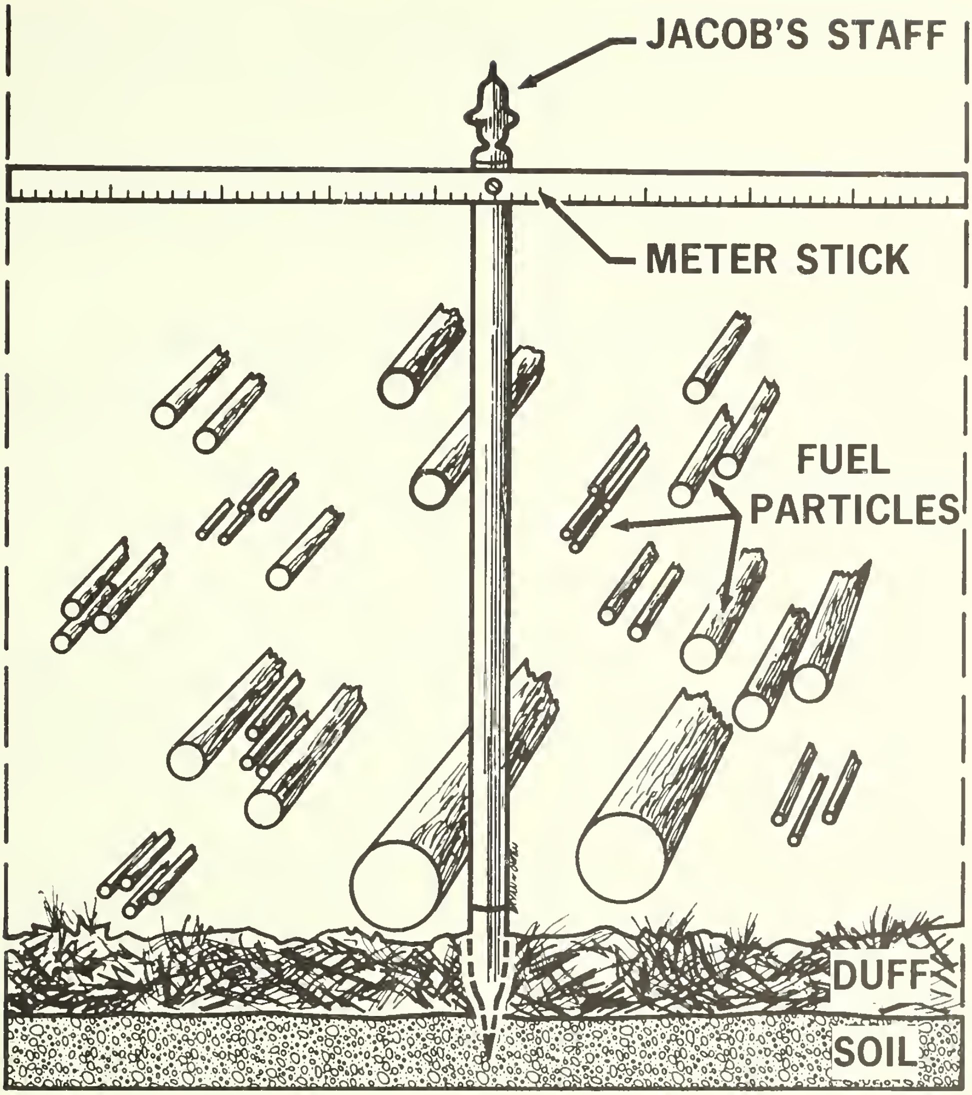


Figure 2.--The diameters of particles intercepted by the imaginary sampling plane are always measured at the points of interception with the plane.

Our sampling scheme follows:

1. A set of sample points is distributed systematically over the study unit (plot).

2. A series of random number lists having different mean values is prepared. Each field unit is assigned an ocular estimate of the average number of twigs per sample point. Based on this ocular estimate, a list is selected from the series for subsampling that unit.

3. The ratio of points at which counts are made, to the total number of points per unit, is calculated to minimize the sampling variation.

4. An observer uses the expected fuel density, the sampling ratio described in item 3 above, and the list of random integers; and visits each of the sampling points and performs the actual field procedure as outlined in the "Field Procedure" section of this text.

Sampling branches (>1 cm, <10 cm).--Woody particles with diameters between 1 and 10 cm were classed as branches. Generally, we found fewer than 10 particles in this size class intercepted each of our 1-m-long planes. Clearly, counting was more efficient than estimating these numbers, so all 1-10 cm intercepts were counted.

Sampling stems (>10 cm).--We tallied approximately one intercept greater than 10 cm per sampling point. Different utilization standards would undoubtedly cause this to change. These intercepts were cull logs, long butts, or unmerchantable boles and tops. Each stem was tallied by its diameter (to the nearest 10 cm) at the point of its interception with the 1-m sampling plane.

Collateral Measurements and Computations

Specific gravity.--Woody fuels were not weighed in the field; rather, fuel volumes were computed from the twig, branch, and stem sample data gathered in the planar intercept sampling. Conversion from volume to weight requires values of specific gravity for each size and species of woody fuel sampled. We used published data (USDA Forest Service 1955) for specific gravity of stems and branches. Specific gravity figures for smaller twigs were lacking, so a number of twigs of each species pertinent to our study were measured and weighed to establish the needed specific gravity values.

Specific gravity determinations were made in terms of ovendry weight. The volume was measured at field moisture levels. Three segments were cut from 25 twigs of each species. These segments, at least 2 cm long, represented the base, midpoint, and tip sections of the twigs. After a period of curing to typical summertime field conditions (7-percent moisture content), the diameters of the segments were measured and each was immersed in mercury. The displacement of mercury was used to determine volume. They were then ovendried and weighed. From these volume and weight measurements specific gravity was computed.

Mean diameters.--Mean diameters for material 0-1 cm in diameter (twigs), by species, were required for use in volume calculations. Needle-bearing twigs, as previously described under "*Sampling Leaves*," were used. The total lengths of the twigs were measured, along with their diameters, at 10-cm intervals. The diameters of tip segments less than 10 cm long were measured at the segment midpoint. Over 10,000 diameter measurements were made. From these measurements a weighted, average green diameter was calculated for each species. Samples were gathered from two widely separated experimental blocks, and we found no significant differences in mean diameters between the blocks. Therefore, the data for each species from both blocks were pooled.

In order to compute mean diameters of branch-size material (1-10 cm), line transects were tallied in the field. On both experimental blocks, the diameters of over 100 branches of each of seven species were measured along randomly oriented lines. As with twigs, branch mean diameters were not significantly different between blocks.

Surface areas.--Twigs, branches, and stems were assumed to be circular cylinders with diameters equal to the mean diameter of their respective size class. We followed procedures outlined by Brown (1970) to determine the surface area-to-volume ratio of leaves and needles.

Volume computations.--The 1-m-long vertical sampling planes were randomly oriented in relation to the direction of slope. They were bounded beneath by the upper surface of the organic forest floor (litter surface), and above by the highest fuel particle passing through the plane. Assuming the fuel particles are circular in cross section and pass through the plane at all angles, we used the following formula to compute volume of fuel sampled on the study units (derivations and discussion of theory were fully covered by Brown [1971]):

$$V = L \frac{nd^2\pi^2}{8}$$

where:

V = volume, cm^3

L = length of fuel particles at right angles to the plane (set at 1 m)

n = number of intercepts, by species and size class

d = mean diameter of the species and size class, cm

Computation of volume of fuel is done in a computer program. As an example, the volume of fuel on a unit, in the 1-10 cm class, is computed as follows:

$$V = \sum_{i=1}^{9} Vi \qquad = LT \frac{\pi^2}{8} \sum_{i=1}^{9} D_i^2 P_i$$

where:

V = volume of fuel on the unit in the 1-10 cm class

Vi = volume of fuel on the unit, in the 1-10 cm class, for individual species (i)

L = assumed length of all intercepts (1 m)

D_i^2 = the average square diameter of the i^{th} species in this size class

i = a number code (1-9) for species

T = the number of intercepts in the 1-10 cm size class for this unit

P_i = the percent frequency for the i^{th} species

FIELD INVENTORY PROCEDURES

Once the optimum number of sampling points for any given inventory job has been determined, a satisfactory distribution of the points is necessary. Our experience has been that a reasonably uniform, rectangular grid is most suitable for efficient, objective sampling in logging slash. As previously described, our final arrangement on each 2 1/2-acre plot was a grid with 1- by 1/2-chain intervals, for a total of 66 sample points.

Field Equipment and Supplies

Following is a list of necessary items to be carried by inventory crews. While not bulky, they are best stored in a many-pocketed vest. Small items should be tied to the vest to prevent loss in the slash.

Item	*Use*
1. Hand compass that is declination-corrected, and has 360° markings.	Plot layout and transect exposure measurement.
2. One-chain trailer tape with topographic corrections.	Plot layout and measurement of distances between transects.
3. Abney level marked with percent scale.	Slope measurements for chaining adjustments and to record slope percent at each transect.
4. Jacob's staff, attached meter stick, and level.	Planar transect establishment and delineation of edges.
5. Port-a-Punch board, stylus, and cards.	Data recording.
6. Steel pocket tape.	Measure slash depth, duff depth, and large log diameters.
7. Gaming die in clear plastic container.	Random orientation of transects.
8. Pocket-size venier calipers.	Measure marginal twig diameters.
9. Random number list.	Determining whether 0-1 cm intercepts must be counted.

Laying Out the Grid

It is usually most efficient to lay out the sampling grid prior to any inventory work. Inventory personnel must exercise great care to avoid bias in the location of the grid intersections. Each intersection is a sample point, and the quantity or position of slash present must not influence judgment about point location.

Sampling a Point

Step 1: Erect a Jacob's staff and attached meter stick (fig. 3) at the sample point.

Step 2: Roll the die to determine meter stick orientation. Multiply die value by 30°, which gives the angle the meter stick should make with the contour. The meter stick is then leveled.

Step 3: Record the exposure of each sample point to the nearest 10°N. azimuth.

Step 4: Measure slope with an Abney level and record to nearest 10 percent.

Step 5: Record duff depth to the nearest 1 cm from the mean of three measurements. Normally the duff measurements will be made at points below the 0-, 50-, and 100-cm divisions of the meter stick. (Duff depth is the vertical distance from the undisturbed duff surface down to the surface of mineral soil.)

Step 6: Slash depth is the vertical distance from the duff surface to the highest fuel particle passing through the sampling plane. Measure this depth with the steel tape and record to the closest decimeter.

Step 7: Discontinuities in the duff are observed along the line of intersection of sampling plane with the earth. The portion of this line comprised of bare mineral soil is recorded to the nearest 10 percent.

Step 8: Up to three tree species contributing to the slash at a sampling point are identified and ranked in order of their percent of contribution. Proportions of aerial fuels in the 0-1 cm diameter class for the two most common species present are recorded to the nearest 10 percent. It is assumed that a third species, if noted, makes up the remaining percentage. A more extensive and precise listing may be designed and used if needed for fuels at other locations.

Step 9: Next, tally number of twigs (0-1 cm). Make an ocular estimate of the number of twigs intercepting the sampling plane. Record this estimate, then read the next number on the list of random numbers.

If the random number is less than the estimated number of intercepts, but not zero, make a count of the twigs. *Always* count the sample point when the estimate of fuel density exceeds a preassigned, estimated maximum fuel density for the unit, regardless of the value of the next random number.

Step 10: Then count the number of branches (1-10 cm diameter) and record.

Step 11: Measure, at the point of interception with the plane, the intercepts larger than 10 cm in diameter and record the diameter to the nearest decimeter. (If the centerline of an intercept passes through the sampling plane, it is recorded.)

Step 12: Record the appropriate code if the sampling point falls on a skid road or other cultural feature.

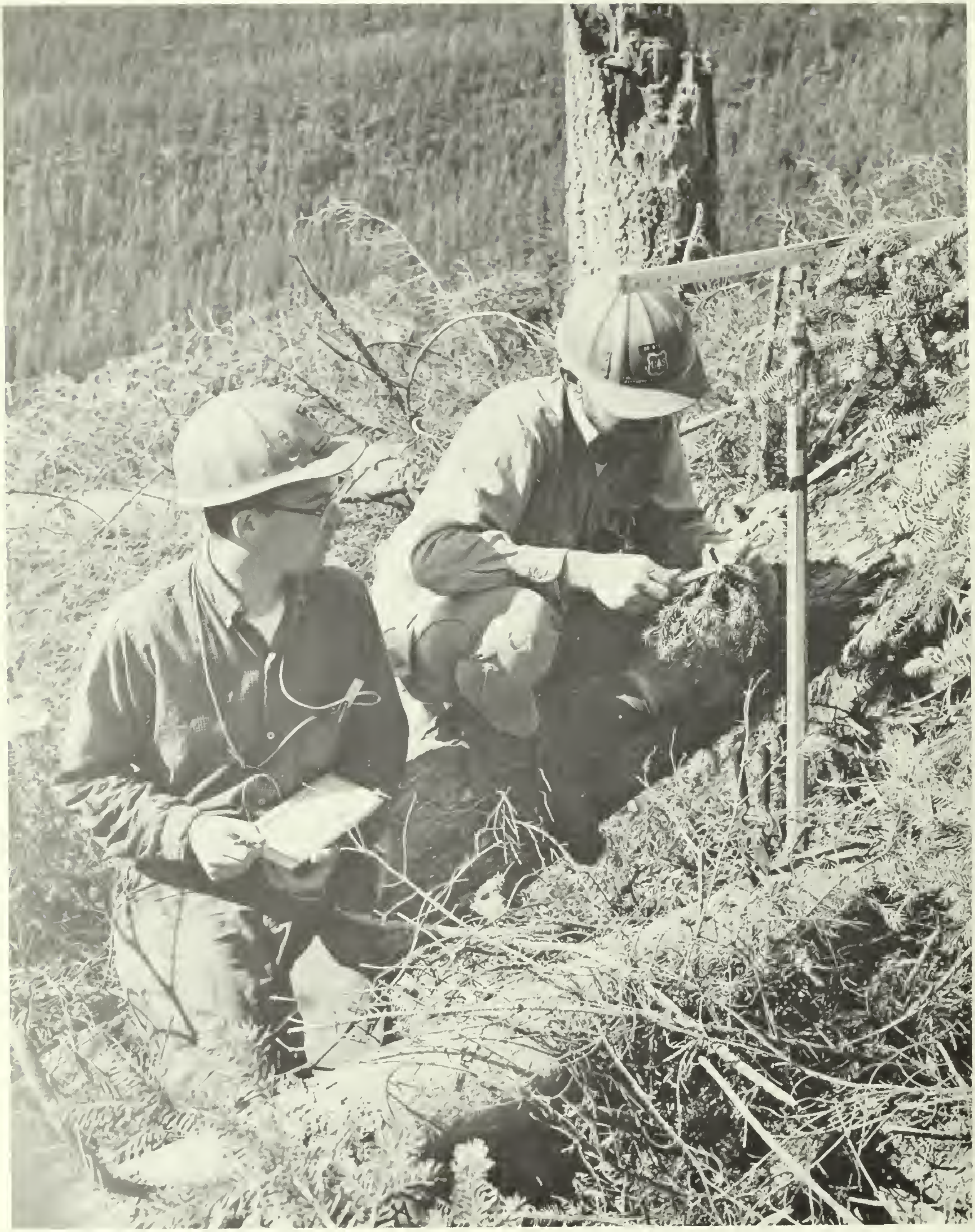


Figure 3.--Sampling planar transects in interior Douglas-fir logging slash. Note the Jacob's staff base for the meter stick.

FIELD DATA RECORDING SYSTEM

For our purposes in the field, punching of data on prescored, 40-column machine cards proved most efficient. IBM Port-a-Punch cards and accessory holders were used. We also found that overprinted legends on the field cards reduced errors in reading and punching. Sample cards and holder are shown in figure 4.

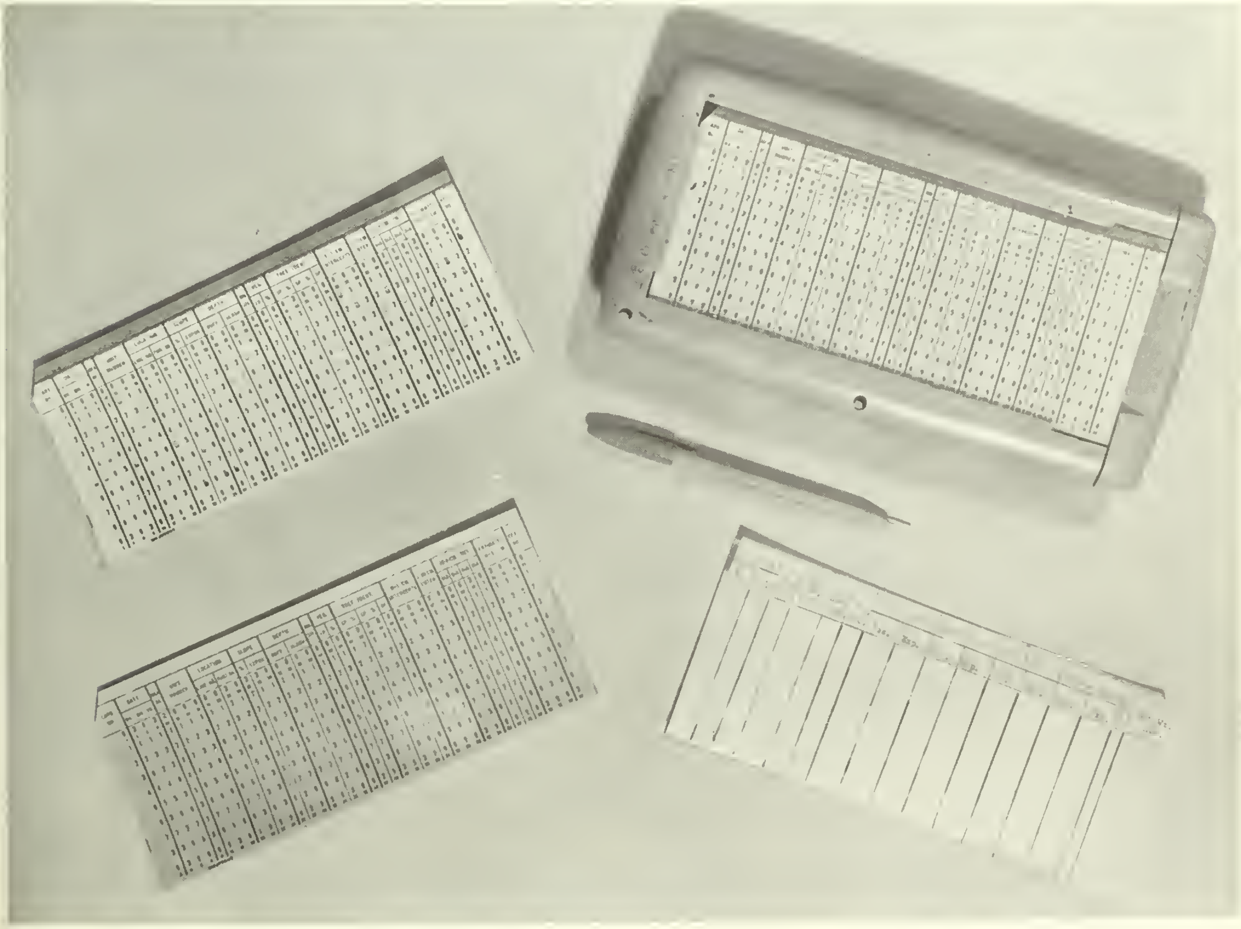


Figure 4.--Port-a-Punch cards, holder, overlay, and stylus. Note the blank prescored cards on the left. A scribed plastic overlay at lower right designates columns.

REDUCTION OF DATA

Preparation of Auxiliary Data

Computation of sampling statistics for twigs (<1 cm obtained by 3P subsampling).--We define density of twigs as the average number of 0-1 cm fuel intercepts per unit of area encountered on a plot (unit). Density and its variance are useful statistics in comparing the fuel loading of one plot with another. 3P fuel sampling should be designed to minimize the variance of the density estimates.

The estimated density of twigs (D) is the corrected total number of 0-1 cm intercepts for all sample points divided by the number of sample points and multiplied by an area conversion factor (F). It is computed as follows:

$$D = F* \left[\frac{1}{n}* \sum^{n} YKPI\right] * \left[\frac{1}{m}* \sum^{m} \left(\frac{YI}{YKPI}\right)\right]$$

where F is the conversion factor from a 1-m transect to a unit of area.

The notation used in this section follows that of Grosenbaugh (1965). T is the estimated total number of twigs for all sample points on a plot, corrected for observer bias. That is:

$$T = \sum^{n} YKPI * \frac{1}{m} \sum^{m} \left(\frac{YI}{YKPI}\right)$$

where:

n = the number of sample points on the plot
YKPI = the estimate of twigs at each sample point
YI = the count of twigs at each sample point where a count was made
m = the number of points at which counts were made

An approximation for the variance of the estimate T is VT.

$$VT = n^2 * \left\{\left(\frac{\overline{YI}}{YKPI}\right)^2 * V\left(\overline{YKPI}\right) + \left(\overline{YKPI}\right)^2 * V\left(\frac{\overline{YI}}{YKPI}\right) \right.$$
$$\left. + 2\left(\overline{YKPI}\right) * \left(\frac{\overline{YI}}{YKPI}\right) * COV\left(\overline{YKPI}, \frac{\overline{YI}}{YKPI}\right)\right\}$$

where $\frac{\overline{YI}}{YKPI}$ is the mean ratio of the count to the estimate, and $\overline{YKPI}$ is the mean estimate, and V $\overline{YKPI}$ is the variance of the mean estimate, and V $\frac{\overline{YI}}{YKPI}$ is the variance of the mean ratio, and COV $\overline{YKPI}$, $\frac{\overline{YI}}{YKPI}$ is covariance of mean estimate to the mean ratio. The sample estimates of the above variances and the covariance are given below.

$$V\left(\overline{YKPI}\right) = \frac{n}{n-1}\left\{\sum^{n}\left(YKPI\right)^{2} - \frac{\left(\sum^{n} YKPI\right)^{2}}{n}\right\}$$

$$V\left(\frac{\overline{YI}}{\overline{YKPI}}\right) = \frac{m}{m-1}\left\{\sum^{m}\left(\frac{YI}{YKPI}\right)^{2} - \frac{\left(\sum^{m}\frac{YI}{YKPI}\right)^{2}}{m}\right\}$$

$$COV\left(\overline{YKPI}, \frac{\overline{YI}}{\overline{YKPI}}\right) = \frac{m}{m-1}\left\{\sum^{m} YI - \frac{\sum^{m} YKPI \sum^{m} \frac{YI}{YKPI}}{m}\right\}$$

Generating the random number table.--For use in this sampling scheme, it is advantageous to use the computer program "THRP" by Grosenbaugh (1965) to prepare the list of random numbers for each plot. The program input parameters are defined by Grosenbaugh in terms of the average expected YKPI for the plot, the desired number of sample points, and the desired number of subsample points (points at which the 0-1 cm particles are counted).

Preliminary sampling.--For each unit inventoried, a sample density (the average number of pieces of fuel per sample point) and the variance of the density are computed for each fuel size class. Using these two statistics, we have a point estimate of the fuel load on each plot *and* an estimate of the variation in fuel placement on the plot. Confidence statements about the fuel density, or tests for difference between plots, can also be constructed from these statistics.

Data Processing Computer Programs

Because the amount of data accumulated by slash fuel inventory is so massive, machine processing is necessary. We compiled plot summaries having estimates of average fuel density and standard error of that estimate, by fuel type. It may be of interest to readers that we employed the inventory system to inventory the fuels again after fire treatment. Data from both the preburn and postburn inventories were processed with the same programs. Because the programs were written specifically for this study they should not be considered to be general purpose summary programs and may not be suitable for use with other sampling schemes. However, for those interested, the programs and ADP card codes are on file at the Northern Forest Fire Laboratory, Missoula, Montana, in mimeograph form, entitled "Data Log, ADP Card Codes, and Programs."

The three major programs used for processing our field inventory data are briefly described below:

1. *Fuel Inventory Program, "3P"*.--The input to this program is preburn inventory data arranged by plot. The program computes, punches on cards, and prints out an adjusted estimate of the average density of fuels in the 0-1 cm size class. Other statistics, such as species distribution, are also printed out.

2. *"Tally-2"*.--This program, together with its subroutines, averages all fuel sizes except the 0-1 cm class. Preburn and postburn inventory data are input.

3. *"FIRESUM"*.--This program computes estimates of fuel volume, surface area, and weight by size class. Its input is the output from "3P" and "Tally-2" plus other data on species characteristics.

INVENTORY RESULTS

Table 1 is an example of fuel inventory summary data obtained by methods outlined earlier--in this case, fuel weight classified by size and exposure. Alternatively, either fuel volume or surface area by species could have been presented along with measures of central tendency.

Table 1.--*Fuel weights before burning by size class and exposure*

Exposure	Size classes							
	0-1		1-10		10+		Needles	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
	Kilograms/square meter							
	MILLER CREEK							
North	0.30	0.07	2.17	0.73	24.17	6.13	0.37	0.09
East	.31	.05	2.31	.61	21.28	4.17	.37	.07
South	.26	.05	2.29	.59	24.11	5.59	.31	.07
West	.28	.08	1.92	.57	22.67	5.01	.33	.09
Average	.29	.07	2.17	.67	23.06	5.35	.35	.09
Range								
Low unit	.19		1.03		11.87		.19	
High Unit	.51		3.76		33.65		.59	
	NEWMAN RIDGE							
North	.24	.07	1.93	.29	24.18	6.42	.38	.14
East	.17	.05	2.23	.67	18.95	3.36	.20	.06
South	.32	.08	3.61	1.13	18.68	4.30	.44	.21
West	.29	.10	3.09	1.23	22.04	4.64	.38	.18
Average	.26	.09	2.71	1.09	20.96	5.05	.35	.18
Range								
Low unit	.11		1.56		13.94		.12	
High Unit	.42		4.77		34.20		.70	

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☆ U.S. GOVERNMENT PRINTING OFFICE: 1974 — 784-490 / 49 REGION NO. 8

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NORTHERN GREAT PLAINS
RESOURCES PROGRAM

SEAM

USDA FOREST SERVICE

REHABILITATION POTENTIALS AND LIMITATIONS OF SURFACE-MINED LAND IN THE NORTHERN GREAT PLAINS

Paul E. Packer

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USDA Forest Service
General Technical Report INT-14, 1974
Intermountain Forest and Range
Experiment Station
Ogden, Utah 84401

The Northern Great Plains Resources Program, an interagency, multi-State effort under leadership of the U.S. Department of the Interior, has the primary objective of providing an analytical and informational framework for policy and planning decisions at all levels of Government. The resource information provided by the Program is intended to be a decision-making tool for Federal, State, and local interests who together must plan and manage the Great Plains area's land and natural resources.

SEAM, an acronym for Surface Environment and Mining, is a Forest Service program to research, develop, and apply technology that will help maintain a quality environment and other surface values while helping meet the Nation's mineral requirements. SEAM is a partnership with all land managers, regional planners, mining industries, and political jurisdictions at all levels.

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This report represents one contribution to the broad Northern Great Plains Resources Program. It is presented under the financial auspices of Program SEAM and as a General Technical Report of the Intermountain Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture. The author gratefully acknowledges assistance of numerous individuals, in the Departments of Agriculture and Interior; the Environmental Protection Agency; various agencies and institutions of the States of North Dakota, South Dakota, Montana, and Wyoming; private industry; and environmental and conservation groups, who contributed to the original report submitted to the Northern Great Plains Resources Program.

USDA Forest Service
General Technical Report INT-14
July 1974

REHABILITATION POTENTIALS AND LIMITATIONS OF SURFACE-MINED LAND IN THE NORTHERN GREAT PLAINS

Paul E. Packer

INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION
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ABSTRACT

Man disturbs his environment by digging into the earth to obtain minerals that satisfy his needs. Society benefits in many ways, but in the process large areas may be defiled and waters polluted. In the case of surface mining for coal in the Northern Great Plains, reclamation may be possible.

The Northern Great Plains coal province occupies approximately 141,448 square miles. Of this, about 4,062 square miles (2.8 percent) of the area, are underlain by surface mineable coal deposits.

An emerging environmental quality problem in the Northern Great Plains is rehabilitation of the spoils left in the wake of mining these coal deposits. Needed are criteria and guides for predicting rehabilitation potentials and limitations on various kinds of surface-mined lands. Equally important is the need to define and prescribe rehabilitation treatments for different kinds of land, and posttreatment management measures.

Important factors influencing the potentials of different kinds of land for growing vegetation and also their rehabilitation with vegetation are (1) amount and distribution of precipitation, (2) soil productivity and stability, and (3) suitability and availability of plant materials for rehabilitation purposes. These factors provide the basis for classifying surface mineable lands in the Northern Great Plains into areas that can reasonably be assumed to have different potentials for supporting seeded and planted vegetation. These areas of land have been named rehabilitation-response units.

Approximately 86 different kinds of rehabilitation-response units involving 146 different areas of land comprise the surface mineable lands of the Northern Great Plains. Sixteen coal surface mines and three bentonite surface mines, located on 14 kinds of rehabilitation-response units, have a history of rehabilitation research or of action programs. These histories provide some short-term evaluations of success for comparison with predicted potentials.

Results of actual rehabilitation efforts indicate the need for certain constraints concerning disposition of toxic spoils, steepness of slopes, mulching, use of fertilizers, application of soil amendments, and irrigation. If such constraints are recognized and observed, the potential for successful rehabilitation of surface-mined lands in the Northern Great Plains ranges from fair to excellent. Sites that have the highest rehabilitation potentials occur in rehabilitation-response units characterized by productive and stable soils, suitable and available plant species, and adequate amounts of precipitation. In general, these high potential sites are in west-central North Dakota. Surface mineable sites that have intermediate rehabilitation potentials occur predominantly in southeastern Montana and extreme western North Dakota. Sites that have the poorest potentials for rehabilitation occur in northeastern Wyoming and northeastern Montana, where rehabilitation-response units are characterized by poorly productive soils, low amounts of precipitation, and native species that grow slowly and are difficult to obtain for rehabilitation purposes.

Fortunately, those portions of the Northern Great Plains that present the most difficult rehabilitation problems are also the smallest areas to be disturbed for a given amount of extracted coal. Conversely, the easiest rehabilitation problems exist in those portions of the Northern Great Plains where the greatest areas of disturbance take place per unit of extracted coal.

OXFORD: 911:268.41
KEYWORDS: land use and regional planning, revegetation, surface mining, coal, western great plains, bentonite, rehabilitation.

CONTENTS

Page

INTRODUCTION 1

STUDY AREA 3

REGIONAL CHARACTERISTICS OF IMPORTANT FACTORS AFFECTING REHABILITATION POTENTIALS 4

- Precipitation Amounts and Distribution 4
- Soil Productivity and Stability 6
- Suitability and Availability of Native Vegetation Types 9

DEVELOPMENT OF REHABILITATION-RESPONSE UNITS AS A CLASSIFICATION SYSTEM FOR REHABILITATION POTENTIALS ON SURFACE-MINED LANDS 12

CLASSIFICATION OF EXISTING SURFACE MINES BY REHABILITATION-RESPONSE UNITS 18

IMPACTS OF DEVELOPMENT OF THE COAL RESOURCE ON SURFACE REHABILITATION 27

- Rating Criteria for Ranking Response Units According to Their Rehabilitation Potentials 27
- Rehabilitation Potential Rankings of Response Units 29
- Implications of Response Unit Rankings for Rehabilitation of Surface Mines in the Sample Counties and Other Areas 31
- Comparison of Rehabilitation-Potential Rankings From Actual Rehabilitation Efforts and From Classification of Response Units 32

CONSTRAINTS AND LIMITATIONS ON REHABILITATION 34

COSTS OF REHABILITATION 38

LEGAL BASIS FOR ENFORCEMENT OF SURFACE-MINE REHABILITATION 39

INFORMATION AND RESEARCH NEEDS 40

ORGANIZATIONS PROMINENTLY ACTIVE IN NORTHERN GREAT PLAINS REHABILITATION WORK 41

CONCLUSIONS 42

LITERATURE CITED 44

INTRODUCTION

Adverse effects on the environment caused by surface coal mining are major national concerns. Americans are aware that the quality of life is directly related to the quality of the environment. Ever-increasing demands for coal, a primary energy source, coupled with technological advancement in extraction techniques, have increased surface mining of coal. Mining and processing coal for energy utilization have often resulted in what is now perceived to be unacceptable degradation of the environment. Effects on the environment have varied, mainly in degree rather than in kind. Surface coal mining has not been a major contributor to air pollution. However, processing coal by combustion to produce energy has resulted in stack emissions and in major air pollution. Consequences of surface mining have been most noticeable on the land. Vegetation has been destroyed, soils turned upside down, and large areas left as bare, unsightly spoil banks. Natural beauty and topography have been greatly altered. Some areas have lost their productivity; only a small percentage of strip-mined lands has been restored. Surface mining for coal has polluted surface and ground water resources in those parts of the country where the coal has a high sulfur content. Fortunately, surface mining for coal in the Northern Great Plains is expected to have less serious effect on water resources than those encountered elsewhere, especially in the eastern coalfields.

Various actions can mitigate undesirable effects of surface mining in the Northern Great Plains. Such actions include: (1) planning when, where, and how much coal or other mineral resources are to be mined consistent with the management of other resources and also with community, regional, and national social and economic needs; (2) incorporation of environmental protection requirements in prospecting and mining leases; (3) employment of appropriate mining techniques; (4) adequate supervision of mining operations; and (5) rehabilitation of disturbed areas.

Rehabilitating surface-mined lands involves shaping spoil piles to desirable configurations, application of available surface soil, and planting of suitable vegetation. Major factors influencing success of a surface-mine rehabilitation program are the chemical, hydrologic, and physical characteristics of reshaped spoil materials as they influence productivity; the climatic characteristics of the site reflected by amounts and distribution of precipitation and the potential for evapotranspiration; and the availability of seeds and propagated plant parts of both native and suitable introduced plant species. Current rehabilitation concepts entail returning sites as nearly as possible to their original condition. Hills and valleys are created to simulate natural variety in the landscape. On drier sites, irrigation can facilitate better or more rapid response of seeded or planted vegetation. Land disturbance involved in rehabilitation treatments often creates conditions conducive to wind and water erosion (e.g., soil may be compacted by some of the operations and sediment levels in streams may be temporarily increased). However, environmental damage resulting from rehabilitation treatments is generally ephemeral and necessary if sites are to be brought to their former or higher productive capacities, to their original or improved vegetation covers, and to their former or more suitable land uses.

The objectives of this report are as follows:

1. To summarize pertinent information relative to important factors that affect rehabilitation potentials on surface-mined lands on the Northern Great Plains. Factors that influence rehabilitation potentials include climate, geology, physiography, soils, availability of adaptable vegetation, mining techniques, and post-mining methods for handling spoils. However, lack of detailed information about these factors applicable on a site-specific basis precludes consideration of more than those few factors that bear most on surface mine-rehabilitation potentials;

2. To arrange those few factors into a system to delineate and classify surface mineable lands into units according to their rehabilitation-response potential;

3. To locate and classify each existing surface mine in the Northern Great Plains within its appropriate rehabilitation-response unit;

4. To describe the history of rehabilitation effort and success at each mine for which information was available in the summer of 1973;

5. To determine the areas of different rehabilitation-response units by States and counties for the three alternative coal resource development forecasts and time periods assumed for the Northern Great Plains;

6. To develop rating criteria and to rate rehabilitation potentials of the particular kinds of response units found in the Northern Great Plains;

7. To weight each rehabilitation-potential rating by the appropriate area of the response unit to which it applies. This method provides a comparative rating of rehabilitation potentials among response units;

8. To compare these rehabilitation-potential ratings with the actual degree of rehabilitation success experienced on individual mines. This comparison will indicate the adequacy of the rating criteria for estimating the rehabilitation potentials of response units;

9. To indicate the nature of problems and the kinds of research relating to rehabilitation potentials that need attention in the Northern Great Plains.

These objectives comprise the sequence of data acquisition, classification, analyses, and interpretation that should result in predictions of potentials for rehabilitating different kinds of land in the Northern Great Plains that might eventually be surface mined. Because of the lack of detailed information concerning results of rehabilitation efforts on the relatively new mines in the Northern Great Plains, it is not expected that the predictive capability emanating from this study will be useful on a site-specific basis. The results of this study will be useful for predicting potential rehabilitation success on larger tracts of land characterized by soil associations, broad vegetative types, and average annual precipitation characteristics. Site-specific information regarding these influencing factors is required to produce site-specific rehabilitation prescriptions.

STUDY AREA

The Northern Great Plains are expansive prairie lands bounded on the west by the Rocky Mountains in Montana and Wyoming. They contain the Northern Great Plains coal province, which occupies approximately the eastern third of Montana, the western half of North Dakota, the northeast quarter of Wyoming, and the northwest tenth of South Dakota. Most of the nation's Federal coal lies in this province.

The largest region in the Northern Great Plains coal province is the Fort Union region which encompasses the western half of North Dakota and parts of South Dakota and Montana. This region contains an estimated 440 billion tons of lignite, by far the largest coal resource in the entire United States (Landis 1973). Most coal is in the Ludlow, Tongue River, and Sentinel Butte members of the Fort Union formation. Coalbeds are discontinuous and vary greatly in thickness. More than a hundred coalbeds have been identified, but no more than three beds of commercial thickness have been found in any one section. Coal throughout most of the Fort Union region is lignite.

The Powder River region, southern extension of the Fort Union region, continues from southern Montana into northeastern Wyoming. This region contains nearly 240 billion tons of sub-bituminous coal (Glass 1972).

The geologic formation containing these coal deposits consists of from 1,700 to 3,200 feet of sandstone, shale, and coal. In general, coalbeds are thickest in Wyoming. Some important coalbeds are the Badger and School seams at Glenrock, the Monarch seam near Sheridan, the Healey bed near Lake Desmet, and the famous Wyodak bed near Gillette.

Bentonite clay beds occur in southeastern Montana, northeastern Wyoming, and the western Dakotas. Bentonite beds are most extensive and bentonite mining more active near the three-State junction of South Dakota, Wyoming, and Montana.

REGIONAL CHARACTERISTICS OF IMPORTANT FACTORS AFFECTING REHABILITATION POTENTIALS

The important factors that determine probabilities for successfully rehabilitating surface-mined lands in the Northern Great Plains are (1) the amount and distribution of precipitation, (2) the productivity and stability of soils, and (3) the suitability and availability of different plant species for revegetation purposes.

Precipitation Amounts and Distribution

According to Thornthwaite (1931), Northern Great Plains climate is generally of the semiarid type. One example of 37 years of observations shows semiarid conditions during 25 years, dry subhumid or arid, 5 years each, humid or moist subhumid, 1 year each, and no years of superhumid conditions, based upon the precipitation-evaporation index (Thornthwaite 1941). Thornthwaite (1941) wrote: "In a desert, you know what to expect of the climate and plan accordingly. The same is true of the humid regions. Men have been badly fooled by the semiarid regions because they are sometimes humid, sometimes desert, and sometimes a cross between the two. Yet, it is possible to make allowances for this too, once the climate is understood." The climate of a region cannot be fully described by a single element such as precipitation or temperature. Climate is comprised of numerous elements such as precipitation, air temperature, soil temperature, humidity, wind velocity, atmospheric pressure, solar terrestrial radiation, and snow cover. Generally, however, only one or two climatic elements preponderantly influence the nature of the climate in any particular region. In the semiarid Northern Great Plains, the most important climatic element that determines relative agricultural success is the amount of seasonal precipitation, coupled with its distribution pattern (Thornthwaite 1931). The frequency of occurrence of different climatic types varies greatly in this area.

In some years, the amount and seasonal distribution of rainfall in the Northern Great Plains is entirely adequate for successful agriculture; in others, the rainfall is so reduced that successful crop production is unlikely. No corresponding risk exists in a continuously arid climate because the weather never encourages agricultural attempts. In the Northern Great Plains, precipitation surpasses that of the semiarid climates with sufficient frequency to encourage agricultural endeavors, but not to assure successful agriculture every year.

Table 1.--*Areas of various precipitation zones on surface-mineable lands by States and counties in the Northern Great Plains*

State and County	Precipitation zones						
	Inches						
	<12	12	13	14	15	16	>16
	Acres						
Wyoming							
Campbell	35,386	76,358	32,282	22,349	29,798	89,395	
Converse	0	17,382	19,866	7,450	0	0	0
Johnson	0	0	0	0	39,731	0	0
Sheridan	0	0	0	0	37,248	0	0
Weston	0	0	0	0	0	0	14,899
Total	35,386	93,740	52,148	29,799	106,777	89,395	14,899
Montana							
Bighorn	0	0	0	39,731	166,374	2,483	0
Custer	0	0	32,282	17,382	39,731	0	0
Dawson	0	12,416	12,416	0	0	0	0
Fallon	0	0	34,765	0	0	0	0
Garfield	0	278,118	0	0	0	0	0
McCone	0	99,328	0	0	0	0	0
Musselshell	0	7,450	2,483	0	0	0	0
Powder River	0	0	0	0	139,059	81,946	22,349
Richland	0	64,563	17,382	7,450	0	0	0
Roosevelt	0	0	17,382	0	0	0	0
Rosebud	0	0	0	7,450	19,866	94,362	22,349
Sheridan	0	0	32,282	0	0	0	0
Treasure	0	0	24,832	4,966	0	0	0
Wilbaux	0	0	0	44,698	0	0	0
Total	0	461,875	173,824	121,677	365,030	178,791	44,698
North Dakota							
Adams	0	0	0	0	0	49,664	0
Billings	0	0	0	0	22,349	0	0
Bowman	0	0	0	0	22,349	0	0
Burke	0	0	0	0	22,349	0	0
Burleigh	0	0	0	0	0	7,450	
Dunn	0	0	0	0	22,349	0	0
Golden Valley	0	0	0	37,248	0	0	0
Hettinger	0	0	0	0	0	109,261	0
McLean	0	0	0	0	9,933	9,933	0
Mercer-Oliver	0	0	0	0	47,181	91,878	0
Slope	0	0	0	24,832	52,147	37,248	0
Stark	0	0	0	0	62,080	34,765	0
Ward	0	0	0	0	7,450	9,933	0
Williams	0	0	0	12,416	9,933	0	0
Total	0	0	0	74,496	278,120	350,132	0
South Dakota							
Butte	0	0	0	52,147	0	0	0
Meade	0	0	0	0	76,979	0	0
Total	0	0	0	52,147	76,979	0	0
TOTALS	35,386	555,615	225,972	278,119	826,906	618,318	59,597

Average annual precipitation in the Northern Great Plains ranges from 8 to 24 inches; the largest portion of the area receives between 10 and 16 inches. More than 90 percent of the surface mineable lands in the Northern Great Plains receive between 12 and 16 inches. The greatest amount of precipitation occurs along the eastern boundary of the region in western North Dakota and in the Black Hills of South Dakota; the least amount falls in northeastern Wyoming and northeastern Montana. Precipitation throughout the region is heaviest from April to September, when up to 75 percent of the annual amount is recorded. Summer rains, usually from the Gulf of Mexico, are mostly thunderstorms. The prevailing wind pattern is from the west or northwest. The western portion of the area is noted for its winds, which quickly dry out soils in summer and drift snow in winter. Normally the area receives less than 1 inch of precipitation per month in winter. The lines of equal precipitation (Isohyetal lines), although subject to some meandering, are north-south oriented; so precipitation generally increases about an inch for every 50 miles of movement eastward. During the growing season, distribution of precipitation is usually favorable for crop production. Rainfall is light in the spring, but increases from April until September, when it is needed most for vegetative growth. From September until December, declining precipitation and abundant sunshine favor maturing of both native and planted crops. A difference of only 1 or 2 inches of rainfall during the growing season can affect significantly the potential for rehabilitating surface-mined lands. Distribution of average annual precipitation in relation to surface mineable lands of the Northern Great Plains coal province is shown in figure 1 (map, back of book). Areas of the various precipitation zones occurring on surface mineable lands by States and counties are shown in table 1.

Soil Productivity and Stability[1]

Forty-two major soil associations are identified within the boundaries of the Northern Great Plains. These soil associations are depicted on Aandahl's (1972) map entitled "Soils of the Great Plains" and also are shown in figure 1. Of these 42 soil associations, only 17 occupy surface mineable areas; consequently, only these 17 soil associations are considered in this report.

Ten of these 17 soil associations are classified by Aandahl as typic (moderately moist) Borolls and Ustorthents. Borolls have horizons of accumulated clay that sometimes contain sodium. Ustorthents are sometimes dry, sometimes moist, receive summer rains, but lack moisture for plant growth for long periods. These 10 soil associations are mainly in western North Dakota, and are identified on Aandahl's soil map and in figure 1 by soil association numbers 19, 23, 25, 26, 27, 30, 31, 33, 34, and 35.

Soil association 44 is classified as Borollic (cold), Torriorthents (nearly always dry) Natrargids (much sodium on clays). This soil association occurs chiefly across the dry central-eastern plains of Montana and the extreme northwest corner of South Dakota.

Five soil associations, 109, 111, 117, 121, and 123, are classified as Ustic (alternately moist and dry), Aridisols (low in organic matter and usually dry), Camborthids-Haplargids (little or no soluble salts or sodium clays). These soil associations are found in southeastern Montana, northeastern Wyoming, and western North Dakota.

Soil association 184 is classified as a badlands Torriorthent (rocky and dry). This soil association is found only in a few places on the extreme fringe of surface mineable lands in the Badlands of the Little Missouri River in western North Dakota.

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[1] Based on removal and replacement of suitable soil strata as a spoil surfacing material.

These 17 soil associations are characterized with respect to their vegetative productivity and their stability as follows:

Soil Association 19.--A fine Argiboroll with a layer of clay accumulation in the C horizon; good productivity; occurs on level-to-undulating topography, slopes generally less than 8 percent; very good stability.

Soil Association 23.--A fine loamy Argiboroll on drier sites than soil association 19, good productivity; occures on level-to-undulating topography; good stability.

Soil Association 25.--A loamy Argiboroll; very good productivity (probably the most productive of the 17 soil associations); occurs on level-to-rolling topography, slopes up to 16 percent; good stability.

Soil Association 26.--A fine loamy Argiboroll; good productivity; occurs on level-to-rolling topography, slopes less than 16 percent; good stability.

Soil Association 27.--A clayey and fine loamy Argiboroll; fairly good productivity; level-to-rolling topography, slopes up to 16 percent; fairly stable.

Soil Association 30.--A loamy and sandy Haploboroll without any distinct accumulation of calcium carbonate, clay, or sodium; fairly good productivity; level-to-rolling topography, slopes up to 16 percent; fairly good stability.

Soil Association 31.--A fine loamy and loamy skeletal lithic Haploboroll; fair productivity; undulating-to-hilly topography, slopes up to 30 percent; poor stability.

Soil Association 33.--A fine silty and fine loamy Haploboroll; fair productivity; undulating-to-hilly topography; slopes up to 30 percent; poor stability.

Soil Association 34.--A fine loamy Ustorthent, with a heavy clay horizon; fair productivity; undulating-to-hilly topography, slopes up to 30 percent; poor stability.

Soil Association 35.--A shallow loamy Ustorthent, with a heavy clay horizon; fair productivity; undulating-to-steep topography, slopes in excess of 30 percent; very poor stability.

Soil Association 44.--A moderately deep loamy Borollic Torriorthent having a large amount of sodium on the clays; fairly poor productivity; undulating-to-hilly topography, slopes up to 30 percent; fairly poor stability.

Soil Association 109.--A clayey and loamy Ustic Aridisol, with a horizon of active or swelling clays; very poor productivity; undulating-to-rolling topography, slopes up to 16 percent; fair stability.

Soil Association 111.--A shallow clayey Ustic Aridisol, with a horizon of active or swelling clays; poor productivity; undulating-to-hilly topography, slopes up to 30 percent; fairly poor stability.

Soil Association 117.--A clayey and loamy Ustic Aridisol having a large amount of sodium on the clays; poor productivity; undulating-to-rolling topography, slopes up to 16 percent; fair stability.

Soil Association 121.--A shallow, loamy, and clayey Ustic Aridisol, dry much of the year; very poor productivity; rolling-to-steep topography, slopes in excess of 30 percent; very unstable.

Table 2.--*Areas of different soil associations occupying surface-mineable lands by States and counties in the Northern Great Plains*

State and County	Soil association																	
	19	21	23	24	25	26	27	30	31	33	35	44	109	111	117	121	123	184
	Acres																	
Wyoming																		
Campbell	0	0	0	0	0	0	0	0	0	0	0	0	0	0	196,173	0	89,395	0
Converse	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29,798	0	14,899	0
Johnson	0	0	0	0	0	0	0	0	0	0	0	0	0	0	17,382	0	22,349	0
Sheridan	0	0	0	0	27,315	0	0	0	0	0	0	0	0	0	0	0	9,933	0
Weston	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	14,899	0	0
Total	0	0	0	0	27,315	0	0	0	0	0	0	0	0	0	243,353	14,899	136,576	0
Montana																		
Bighorn	0	0	0	0	29,798	0	0	0	19,866	0	0	0	0	0	104,294	0	54,630	0
Custer	0	0	0	0	0	0	0	0	54,630	0	0	17,382	0	0	0	0	17,382	0
Dawson	0	0	0	0	0	12,416	0	0	0	12,416	0	0	0	0	0	0	0	0
Fallon	0	0	0	0	0	0	0	0	0	0	0	34,765	0	0	0	0	0	0
Garfield	0	0	0	0	0	0	0	0	0	0	0	193,690	0	0	0	0	0	84,429
McCone	0	0	0	0	0	9,933	0	0	0	4,966	0	74,496	0	0	0	0	0	9,933
Musselshell	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9,933	0
Powder River	0	0	0	0	0	0	0	0	193,690	0	0	0	0	0	14,899	0	34,765	0
Richland	0	0	0	0	0	52,147	0	0	0	29,798	7,450	0	0	0	0	0	0	0
Roosevelt	0	0	0	0	0	17,382	0	0	0	0	0	0	0	0	0	0	0	0
Rosebud	0	0	0	0	0	0	0	0	101,811	0	0	0	0	0	0	0	42,214	0
Sheridan	0	0	12,416	0	0	19,866	0	0	0	0	0	0	0	0	0	0	0	0
Treasure	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	29,158	0
Wilbaux	0	0	0	0	0	0	29,798	0	0	7,450	7,450	0	0	0	0	0	0	0
Total	0	0	12,416	0	29,798	111,744	29,798	0	369,997	54,630	14,900	320,333	0	0	119,193	0	188,082	94,362
North Dakota																		
Adams	0	0	0	0	7,450	0	0	42,214	0	0	0	0	0	0	0	0	0	0
Billings	0	0	0	22,349	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Bowman	0	0	0	4,966	17,382	0	0	0	0	0	0	0	0	0	0	0	0	0
Burke	22,349	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Burleigh	7,450	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dunn	0	0	0	4,966	0	0	0	17,382	0	0	0	0	0	0	0	0	0	0
Golden Valley	0	0	0	0	0	0	29,798	0	0	7,450	0	0	0	0	0	0	0	0
Hettinger	0	0	0	0	94,362	0	0	14,899	0	0	0	0	0	0	0	0	0	0
McLean	9,933	9,933	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mercer-Oliver	34,765	7,450	24,832	0	12,416	0	0	0	0	0	59,596	0	0	0	0	0	0	0
Slope	0	0	0	34,764	47,181	0	0	0	0	0	29,798	0	0	0	0	0	0	2,483
Stark	0	0	0	49,664	14,899	0	0	12,416	0	0	19,866	0	0	0	0	0	0	0
Ward	17,382	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Williams	2,483	0	0	0	0	0	0	0	0	0	19,866	0	0	0	0	0	0	0
Total	94,362	17,383	24,832	116,689	193,690	0	29,798	86,911	0	7,450	129,126	0	0	0	0	0	0	2,483
South Dakota																		
Butte	0	0	0	0	0	0	0	0	0	0	0	37,248	0	14,899	0	0	0	0
Meade	0	0	0	0	0	0	0	0	0	0	0	0	76,979	0	0	0	0	0
Total	0	0	0	0	0	0	0	0	0	0	0	37,248	76,979	14,899	0	0	0	0
TOTALS	94,362	17,383	37,248	116,689	250,803	111,744	59,596	86,911	369,997	62,080	144,026	357,581	76,979	14,899	362,546	14,899	324,658	96,845

Soil Association 123.--A shallow, loamy, and clayey Ustic Aridisol, dry much of the year, that has a large amount of sodium on the clays; poor productivity; undulating-to-hilly topography, slopes up to 30 percent; poor stability.

Soil Association 184.--A loamy and clayey Torriorthent, dry much of the year, very poor productivity; undulating-to-steep Badlands, slopes in excess of 30 percent; very poor stability.

Soil tests and field trials indicate that soils in Montana and Wyoming and west of the Missouri River in North Dakota are conspicuously deficient in phosphorus. Response to phosphorus fertilizer is less consistent in the drier western part of the region than in the more moist regions east of the Missouri River in North Dakota. Nitrogen is generally more deficient in the moister part of North Dakota than it is in eastern Montana and eastern Wyoming. Where nitrogen is deficient, little or no response is obtained from phosphate fertilizer unless nitrogen is also provided.

Erosion is a serious problem in some localities of the Northern Great Plains. Sandy soils are highly erodible because they do not contain enough silt and clay for large aggregates to form. Repeated freezing and thawing and wetting and drying result in formation of aggregates of a size susceptible to wind and water actions. Soils high in clay are most subject to this type of erosion. Areas of the different soil associations occupying surface mineable lands by States and counties are shown in table 2.

Suitability and Availability of Native Vegetation Types

Plants of the Northern Great Plains coal province are mostly such grass species as wheatgrasses, needlegrasses, grama grasses, bluestems, and fescues. Overgrazing by buffalo and later by livestock has resulted in an increase in sagebrushes and rabbit brushes in these grasslands, especially the short-grass prairies. All native grasses in the Northern Great Plains grow well under the favorable precipitation-temperature pattern. The cold-desert biome, dominated by sagebrush, and the montane-coniferous forest biome, dominated by ponderosa pine, also occur in the Northern Great Plains. Cottonwood, willow, and ash of the deciduous forest biome dominate the gully bottoms along rivers and their tributaries. Fourwing saltbush, found along the drainages, and inland saltgrass indicate alkaline or saline areas. Frequently, sand sage and prairie sandreed occupy sandy areas. Sixteen broad, but recognizable, vegetation types have been delineated in the Northern Great Plains coal province (fig. 1). Nine of these 16 vegetation types occur on surface mineable areas. They are the only vegetation types that will be considered in regard to rehabilitation potential. A brief description of these vegetation types in respect to their suitability and availability for rehabilitation is presented. To permit comparison, the corresponding Kuchler (1964) vegetation type number is also shown. Vegetation types are as follows:

Floodplain (type 1, Kuchler type 98).--This vegetation type occurs on the bottom lands and banks of major rivers and on broad floodplain terraces that have alluvial soils. It occupies sites, some highly saline, that have high water tables. The floodplain type is characterized predominantly by hardwood tree and shrub species that are poorly suitable and poorly available for rehabilitation.

Badlands (type 2, Kuchler has no type number for the Badlands).--This vegetation type occupies breaks along rivers and streams and steep south slopes of exposed shales, sandstones, and clays. Dominant plant species are arid-land shrubs and grasses associated locally with scabby ponderosa pine forests. The species that characterize this type are poorly suitable and poorly available for rehabilitation.

Short-Grass Prairie (type 3, Kuchler type 64).--This vegetation type occupies dry prairies on shallow soils in southeastern Montana and northeastern Wyoming. Dominant species are blue grama grass, western wheatgrass, and various needlegrasses. The species that characterize this type have moderately poor suitability and fair availability for rehabilitation.

Mid-Short Grass Prairie (type 4, Kuchler types 64 and 66).--This type occupies rolling prairies on loam to clay loam soils in eastern Montana. It is characterized by western wheatgrass, needle-and-thread grass and blue grama grass. These species have moderately poor suitability and fair availability for rehabilitation.

Mid-Grass Prairie (type 5, Kuchler type 66).--This type, which occurs on loamy soils in extreme eastern Montana, southwestern North Dakota, and northwestern South Dakota, contains no dominant short grass. Principal species are needlegrasses, wheatgrasses, and blue stem grasses. Most species that comprise this type are fairly suitable and have good availability for rehabilitation.

Grassland-Sagebrush (type 6, Kuchler type 56).--This vegetation type occurs on open grassland of mid and short grasses, with scattered sagebrush, and occurs on silty clay loam soils in southeastern Montana and northeastern Wyoming. Most of the species that comprise this type have good suitability and moderately good availability for rehabilitation.

Sagebrush-Steppe (type 7, Kuchler type 55).--This type is dominated by sagebrush in open grassland containing wheatgrasses and needle-and-thread on silt to silty clay loam soils. It occurs chiefly in northeastern Wyoming and most of the major species have moderately good suitability, but are relatively unavailable for rehabilitation.

Mid-Tall Grass Prairie (type 9, Kuchler type 67). This vegetation type occurs on gently rolling prairie northeast of the Missouri River in North Dakota, and is characterized by wheatgrasses, big and little bluestem grasses, and needlegrasses on loam soils of glacial till origin. Nearly all species in this type have good suitability and availability for rehabilitation.

Ponderosa Pine Forest (type 12, Kuchler type 16).--This vegetation type occurs mainly in eastern Montana and northeastern Wyoming on uplands, ridges, and north slopes that have shallow loam soils. Prominent species are ponderosa pine, snowberry, blue grasses, fescues, and June grass. These species are only fairly suitable, but have good availability for rehabilitation.

These native vegetation types and their species represent the potential for reestablishment of native plant cover on surface-mined areas where surface soil has been replaced. In some portions of the Northern Great Plains, where higher precipitation and more fertile soils occur, surface-mined lands may be restored to agricultural uses rather than to native cover types. In some instances, surface-mined lands may lend themselves to such other uses as development of parks, lakes, marshes, or woodlands. Where such opportunities exist, they should be developed, but they require careful planning of mining and post-mining activities. Except for rehabilitating agricultural lands (largely in North Dakota) and for occasional specialized reclamation opportunities, the greatest potential for rehabilitating surface-mined lands in the study area lies in using native plant species that characterize each area. Areas of different vegetation types occupying surface mineable lands by State and by county are shown in table 3.

Table 3.--*Areas of different vegetation types occupying surface-mineable lands by States and counties in the Northern Great Plains*

State and County	Vegetation type								
	1	2	3	4	5	6	7	9	12
	Acres								
Wyoming									
Campbell	0	0	0	0	0	176,282	96,845	0	12,416
Converse	0	0	0	0	0	42,214	0	0	2,483
Johnson	0	0	0	0	9,933	29,798	0	0	0
Sheridan	7,450	0	0	0	0	19,866	4,966	0	4,966
Weston	0	0	14,899	0	0	0	0	0	0
Total	7,450	0	14,899	0	9,933	268,160	101,811	0	19,865
Montana									
Bighorn	4,966	0	0	44,698	0	144,026	0	0	14,899
Custer	0	0	64,563	4,966	0	7,450	0	0	12,416
Dawson	0	0	0	7,450	17,382	0	0	0	0
Fallon	0	0	24,832	9,933	0	0	0	0	0
Garfield	0	49,664	0	196,173	0	0	0	0	32,282
McCone	0	4,966	0	59,597	34,765	0	0	0	0
Musselshell	0	0	0	0	0	0	0	0	9,933
Powder River	0	0	44,698	0	0	111,744	14,899	0	72,013
Richland	0	0	0	7,450	81,946	0	0	0	0
Roosevelt	0	0	0	0	17,382	0	0	0	0
Rosebud	7,450	0	0	14,899	0	76,979	0	0	44,698
Sheridan	0	0	0	0	32,282	0	0	0	0
Treasure	0	0	0	29,798	0	0	0	0	0
Wilbaux	0	2,484	0	0	42,214	0	0	0	0
Total	12,416	57,114	134,093	374,964	225,971	340,199	14,899	0	186,241
North Dakota									
Adams	0	0	0	0	49,644	0	0	0	0
Billings	0	0	0	0	22,349	0	0	0	0
Bowman	0	0	0	0	22,349	0	0	0	0
Burke	0	0	0	0	0	0	0	22,349	0
Burleigh	0	0	0	0	7,450	0	0	0	0
Dunn	0	0	0	0	22,349	0	0	0	0
Golden Valley	0	0	0	0	37,248	0	0	0	0
Hettinger	0	0	0	0	109,261	0	0	0	0
McLean	0	0	0	0	19,866	0	0	0	0
Mercer-Oliver	12,416	0	0	0	126,643	0	0	0	0
Slope	0	2,483	0	0	109,261	0	0	0	2,483
Stark	0	0	0	0	96,845	0	0	0	0
Ward	0	0	0	0	7,450	0	0	9,933	0
Williams	0	0	0	0	22,349	0	0	0	0
Total	12,416	2,483	0	0	653,064	0	0	32,282	2,483
South Dakota									
Butte	0	0	0	0	52,147	0	0	0	0
Meade	0	0	0	0	76,979	0	0	0	0
Total	0	0	0	0	129,126	0	0	0	0
TOTALS	32,282	59,597	148,992	374,964	1,018,094	608,359	116,710	32,282	208,589

DEVELOPMENT OF REHABILITATION-RESPONSE UNITS AS A CLASSIFICATION SYSTEM FOR REHABILITATION POTENTIALS ON SURFACE-MINED LANDS

In developing this report the author has assumed that--within the constraints of map scale and detail of information available--three major environmental factors influence the potential for rehabilitating surface-mined land in the Northern Great Plains: (1) the productivity and stability characteristics of surface soil materials; (2) the suitability of native plant species for plant cover reestablishment and their availability for the purpose; and (3) the amount and distribution of precipitation. The surface mineable lands in the Northern Great Plains occur in 17 soil associations, in 9 broad vegetative types, and in 7 annual precipitation zones ranging from less than 12 to more than 16 inches by 1-inch increments. If these 17 soil associations, 9 vegetative types, and 7 precipitation zones occurred together in all possible combinations, they would aggregate 1,071 different areas. All possible combinations do not occur on the surface mineable lands in the Northern Great Plains; these factors combine to delineate 86 different combinations on the ground. Thus, the surface mineable area in the Northern Great Plains can be divided into 86 different kinds of land, each with its own rehabilitation-potential characteristics. Most combinations are found in more than one location; thus, the surface mineable area of the Northern Great Plains contains a total of 146 rehabilitation-response units.

Each rehabilitation-response unit is identified by three sets of numbers (table 4). The first number, containing either two or three digits, refers to the Aandahl soil association number; the second, containing either one or two digits, refers to the vegetation type number; and the third, containing two digits, refers to the precipitation zone in which the unit is located. For example, rehabilitation-response unit 117-6-14 is a tract of surface mineable land located in Ustic Aridisol soil association 117, on grassland-sagebrush vegetation type 6, in a 14-inch-per-year precipitation zone. These combined characteristics place this particular kind of rehabilitation-response unit in east-central Campbell County, Wyoming. Presumably, regardless of location, rehabilitation-response units that have the same soil-vegetation-precipitation identifications should exhibit essentially the same response to similar rehabilitation efforts in a comparable time period. Rehabilitation-response units have been numbered from 1 through 86. The same number on more than one response unit indicates more than one tract of land in that response-unit category. All rehabilitation-response units that comprise surface mineable lands are shown by location and number in figure 2 (map, back of book). They are also tabulated in table 4 by number and acreage for States and counties. The total acreage of all rehabilitation-response units, which is the total surface mineable area in the Northern Great Plains coal province, is 2,599,913 acres, or 4,062 square miles.

Table 4.--*Kinds and areas of rehabilitation-response units on surface-mineable lands of the Northern Great Plains*

State and County	Rehabilitation-response unit				
	Identification number			Map location number	Area
	Soil	Vegetation	Precipitation		
					Acres
Wyoming					
Campbell	117	6	14	1	14,899
	117	7	16	2	27,315
	117	6	16	3	17,382
	117	7	15	4	14,899
	117	6	12	5	58,976
	117	6	11	6	35,386
	117	6	13	7	27,315
	123	6	15	9	4,966
	123	7	16	8	44,698
	123	7	15	10	9,933
	123	12	11	12	12,416
	123	6	12	13	4,966
	123	6	13	14	4,966
	123	6	14	15	7,450
Total					285,568
Converse	117	6	13	7	19,866
	117	6	14	1	7,450
	117	6	12	5	2,483
	123	6	12	13	12,416
	123	12	12	11	2,483
Total					44,698
Johnson	117	5	15	21	7,450
	117	6	15	22	9,933
	123	6	15	9	19,866
	123	5	15	20	2,483
Total					39,731
Sheridan	25	1	15	17	2,483
	25	6	15	19	19,866
	25	12	15	18	4,966
	123	1	15	16	4,966
	123	7	15	10	4,966
Total					37,248
Weston	121	3	18	23	14,899
Total					14,899
TOTAL					422,144

(con. next page)

Table 4.--(con.)

State and County	Rehabilitation-response unit				
	Identification number			Map location number	Area
	Soil	Vegetation	Precipitation		
					Acres
Montana					
Bighorn	25	6	15	19	17,382
	25	12	15	18	12,416
	31	6	15	26	12,416
	31	6	16	27	2,483
	31	4	15	39	4,966
	117	6	15	22	96,845
	117	1	15	40	4,966
	117	12	15	41	2,483
	123	6	15	9	14,899
	123	4	14	37	39,731
Total					208,589
Custer	31	3	15	28	32,282
	31	3	14	31	14,899
	31	6	15	26	7,450
	44	3	13	46	14,899
	44	12	13	47	2,483
	123	3	14	32	2,483
	123	12	13	44	9,933
	123	4	13	42	4,966
Total					89,395
Dawson	26	4	13	62	7,450
	26	5	13	61	4,966
	33	5	12	59	12,416
Total					24,832
Fallon	44	3	13	46	24,832
	44	4	13	48	9,933
Total					34,765
Garfield	44	4	12	53	188,723
	44	12	12	54	4,966
	184	2	12	55	49,664
	184	12	12	56	27,315
	184	4	12	57	7,450
Total					278,118
McCone	26	5	12	58	9,933
	33	5	12	59	4,966
	44	5	12	60	19,866
	44	4	12	53	54,630
	184	2	12	55	4,966
	184	4	12	57	4,966
Total					99,328

(con. next page)

Table 4.--(con.)

State and County	Rehabilitation-response unit				
	Identification number			Map location number	Area
	Soil	Vegetation	Precipitation		
					Acres
Montana (con.)					
Musselshell	123	12	12	11	7,450
	123	12	13	43	2,483
Total					9,933
Powder River	31	12	15	25	34,765
	31	6	15	26	9,933
	31	6	16	27	47,181
	31	3	15	28	44,698
	31	6	17	29	22,349
	31	12	16	30	34,765
	117	6	15	22	14,899
	123	12	15	24	2,483
	123	6	15	9	17,382
	123	7	15	10	14,899
Total					243,354
Richland	26	5	12	58	34,765
	26	5	13	61	9,933
	26	4	13	62	7,450
	33	5	12	59	29,798
	35	5	14	51	7,450
Total					89,395
Roosevelt	26	5	13	61	17,382
Total					17,382
Rosebud	31	6	16	27	42,214
	31	1	16	33	7,450
	31	12	16	30	27,798
	31	6	17	29	17,382
	123	12	16	35	7,450
	123	6	15	9	9,933
	123	6	16	36	7,450
	123	4	14	37	7,450
	123	4	15	38	7,450
	123	12	15	24	2,483
Total					144,026
Sheridan	23	5	13	63	12,416
	26	5	13	61	19,865
Total					32,281
Treasure	123	4	13	42	24,832
	123	4	14	37	4,966
Total					29,798

(con. next page)

Table 4.--(con.)

State and County	Rehabilitation-response unit				
	Identification number			Map location number	Area
	Soil	Vegetation	Precipitation		
					Acres
Montana (con.)					
Wilbaux	27	5	14	49	29,798
	33	5	14	50	4,966
	33	2	14	52	2,483
	35	5	14	51	7,450
Total					44,698
TOTAL					1,345,894
North Dakota					
Adams	30	5	16	86	42,214
	25	5	16	72	7,450
Total					49,664
Billings	24	5	15	76	22,349
Total					22,349
Bowman	24	5	15	76	4,966
	25	5	15	78	17,382
Total					22,349
Burke	19	9	15	75	22,349
Total					22,349
Burleigh	19	5	16	64	7,450
Total					7,450
Dunn	24	5	15	76	4,966
	30	5	15	77	17,382
Total					22,349
Golden Valley	27	5	14	49	29,798
	33	5	14	50	7,450
Total					37,248
Hettinger	30	5	16	86	14,899
	25	5	16	72	94,362
Total					109,261
McLean	21	5	15	67	9,933
	19	5	16	64	9,933
Total					19,866
Mercer-Oliver	19	5	16	64	22,349
	19	1	15	65	4,966
	19	1	16	66	2,483
	19	5	15	73	4,966

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Table 4.--(con.)

State and County	Rehabilitation-response unit				
	Identification number			Map location number	Area
	Soil	Vegetation	Precipitation		
					Acres
North Dakota (con.)					
Mercer-Oliver	21	5	15	67	7,450
(con.)	23	5	16	68	24,832
	25	5	16	72	12,416
	35	5	16	69	24,832
	35	5	15	70	29,798
	35	1	16	71	4,966
Total					139,059
Slope	24	5	16	85	4,966
	24	5	14	79	12,416
	24	5	15	76	17,382
	25	5	15	78	14,899
	35	5	15	70	17,382
	35	5	14	51	9,933
	35	2	14	81	2,483
	184	12	15	80	2,483
	25	5	16	72	32,282
Total					114,227
Stark	35	5	16	45	19,866
	24	5	15	76	49,664
	30	5	15	77	12,416
	25	5	16	72	14,899
Total					96,845
Ward	19	5	16	64	7,450
	19	9	16	74	2,483
	19	9	15	75	7,450
Total					17,382
Williams	19	5	15	73	2,483
	35	5	14	51	12,416
	35	5	15	70	7,450
Total					22,349
TOTAL					702,748
South Dakota					
Butte	44	5	14	82	37,248
	111	5	14	83	14,899
Total					52,147
Meade	109	5	15	84	76,979
Total					76,979
TOTAL					129,126

CLASSIFICATION OF EXISTING SURFACE MINES BY REHABILITATION-RESPONSE UNITS

Approximately 27 surface coal mines in the Northern Great Plains are either mining or are expected to mine coal in sufficient quantities to warrant concern for reclamation and rehabilitation of disturbed areas. Locations of these mines in relation to the rehabilitation-response units of the Northern Great Plains are shown in figure 2. Five of the mines shown in table 5 either are proposed or are in the developmental stage; consequently, they have no rehabilitation history.

Six of these 27 mines either have been operated in the past or are operating now (table 6); however, none of them has a firm enough history of rehabilitation to be included in this report.

Besides the six surface coal mines listed in table 6, mine 28 (the Hallett Minerals bentonite mine), is operating in Treasure County, Montana, on rehabilitation response unit 41-3-12. A rehabilitation program has been planned, but has not yet been implemented.

Either rehabilitation research or a rehabilitation-action program has been instigated for each of the remaining 16 surface coal mines and 3 large bentonite mines (table 7). Their rehabilitation experience or history will be described. The Soil Conservation Service has initiated adaptability tests of a large number of plant species on some of these mines. These studies are not yet completed. Accordingly, no attempt has been made to evaluate that testing program in this report.

These mines are on 14 different rehabilitation-response units. Thus, of the 86 rehabilitation-response units on surface mineable lands in the Northern Great Plains, results of rehabilitation research or applied rehabilitation treatments are available for only about 17 percent of the rehabilitation-response units. Fortunately, these mines are distributed over a sufficiently varied range of rehabilitation-response units to allow some interpolation of rehabilitation results.

Table 5.--*Proposed or undeveloped major surface coal mines*

State and County	Mine No.	Mining company	Rehabilitation-response unit
Wyoming			
Campbell	10	Kerr-McGee Co.	117-6-11
	7	Carter Oil Co.	123-12-14
	8	Atlantic-Richfield Co.	117-6-11
Johnson	9	Reynolds Metals Co.	117-6-15
Sheridan	6	Welch Coal Co.	25-12-15

Table 6.--*Major surface coal mines for which no rehabilitation data nor experience are available*

State and County	Mine No.	Mining company	Rehabilitation-response unit
Wyoming			
Converse	3	Best Coal Co.	123-6-10
Montana			
Musselshell	16	Reliable Coal Co.	123-12-12
North Dakota			
Adams	27	Arrowhead Coal Co.	25-5-15
Burke	24	Bonsness Coal Co.	19-9-15
McLean	25	Underwood Coal Co.	19-5-16
Stark	26	Husky-Briquetting Co.	30-5-16

Table 7.--*Coal and bentonite surface mines on which surface rehabilitation activities have occurred*

State and County	Mine No.	Mining company and mine	Rehabilitation-response unit
		COAL OPERATIONS	
Wyoming			
Campbell	1	Wyodak Resources Development Co. (Wyodak)	117-6-14
	2	AMAX Coal Co. (Belle Ayr)	117-6-13
Converse	4	Pacific Power & Light Co. (Glenrock)	123-6-14
Sheridan	5	Bighorn Coal Co. (Bighorn)	25-6-15
Montana			
Bighorn	11	Decker Coal Co. (Decker)	117-6-15
	12	Westmoreland Coal Co. (Sarpy Creek)	31-4-14
Rosebud	13	Peabody Coal Co. (Colstrip)	31-12-16
	14	Western Energy Co. (Colstrip)	31-12-16
Richland	15	Knife River Coal Co. (Savage)	26-5-13
North Dakota			
Oliver	20	Baukal-Noonan Co. (Center)	35-5-16
Mercer	21	North American Coal Co. (Zap)	35-5-16
	22	Knife River Coal Co. (Beulah)	23-5-16
	23	Consolidation Coal Co. (Stanton)	35-5-16
Burke	24	Baukal-Noonan Co. (Noonan Strip)	19-9-15
McHenry	25	Consolidation Coal Co. (Velva)	19-9-16
Adams	26	Knife River Coal Co. (Gascoyne)	25-5-15
		BENTONITE OPERATIONS	
Montana			
Carter	29	International Minerals & Chemical Co. (Carter)	111-5-14
	30	American Barroid Co. (Carter)	111-5-14
	31	Federal Minerals Co. (Carter)	111-5-14

A brief description of rehabilitation efforts and results on the surface mines listed in table 7 follows:

1. *Wyodak Resources Development Co. (Wyodak).*--This mine is on the Wyodak seam in northeastern Wyoming. The top 10 feet of overburden is sandy and has no adverse chemical characteristics. Spoil banks have been graded to a level or gently sloping configuration. An action program was instituted to revegetate the completed areas of spoil banks. In the spring of 1972, areas were lightly disked and seeded to crested wheatgrass, green needlegrass, western wheatgrass, and fourwing saltbush. No supplemental irrigation was applied. Excellent stands were obtained by planting on spoils from both shallow and deep depths; however, vigor of stands grown on spoil banks derived from shallow depths was better. Short-term conclusions about this mine are that (1) the overburden from deep depths is not toxic, (2) spoil banks finished off with near-surface material provide better growth, (3) rehabilitation can be accomplished without irrigation, and (4) good rehabilitation success can be achieved on rehabilitation-response unit 117-6-14.

2. *AMAX Coal Co. (Belle Ayr).*--This mine is on the Wyodak seam in northeastern Wyoming. The overburden, which consists of mixed sandstone, claystone, and shale, is quite sandy. No toxic or sterile overburden has been encountered. As at the Wyodak mine, the upper 10 feet of overburden is best for final emplacement on graded spoils. Spoils have been shaped to gentle slopes similar to the natural topography. No serious erosion problems exist. AMAX, the University of Wyoming, and the Forest Service have established successful rehabilitation plantings on this mine. AMAX and the Soil Conservation Service have initiated small-scale test rehabilitation programs. AMAX has planted most of the areas that have been rehabilitated. Approximately 400 acres, used for spoil disposal from the mine pit, have been planted to grasses, forbs, and shrubs and developed into a cattle grazing enterprise. Another 25 acres, more or less, have been planted to protect and stabilize mine spoils. The University of Wyoming has successfully established a number of grass and legume species on an experimental area of only a few acres. Similarly, the Forest Service has an experimental planting of several shrub and tree species (225 of each species), some of which have established successfully.

Among the grass and shrub species that have been successfully grown on the Belle Ayr mine are western wheatgrass, green needlegrass, tall wheatgrass, and four wing saltbush. No mulches, soil amendments, or irrigation have been used in connection with these plantings. Some have been fertilized, however.

This mine is representative of rehabilitation-response unit 117-6-13. Short-term conclusions based on results of rehabilitation efforts are that (1) grading of spoils to gentle slopes reduces or eliminates erosion of the soil surface; (2) fertilizer improves initial growth while the ground is still moist, but apparently does not enhance survival after the ground dries; (3) native and adapted introduced grasses and shrubs establish and survive well, especially where the top 10 feet of overburden has been used to finish off the spoil surface; and (4) in years of average and above-average precipitation, initial establishment of adaptable plant species should not be difficult on this rehabilitation-response unit.

4. *Pacific Power and Light Company (Glenrock).*--Overburden at this mine consists of mixed sandstone, claystone, and shale, and is quite sandy. Toxic or sterile overburden caused by excessive sodium has been identified, but only in clay materials at great depths near the coal seams. As at the Wyodak and Belle Ayr mines, the upper 10 feet of overburden has been found to be best for final surfacing on graded spoils. The

sandy overburden strata ranging from about 10 to 60 feet in depth are also suitable, although not quite as desirable as the topmost layers for supporting plant growth. This mine has been operated since 1958. Rehabilitation activities were begun in 1964, and approximately 550 acres of spoils have been revegetated. Those areas reseeded between 1964 and 1969 did not develop completely satisfactory stands of vegetation. Beginning in 1970, the company's Environmental Group developed new and better techniques for revegetating spoils. These techniques include using such native species as western and thick-spike wheatgrasses and green needlegrass; grading spoils to slopes of less than 3:1; contour farming practices; and cross-slope disking of large amounts of straw mulch into the surface spoils. Since 1971, the company has reseeded all spoils on which unsatisfactory plant cover had developed prior to 1970. Currently, their rehabilitation program follows mining by from 6 months to a year.

The first fertilizer used by this company was an aerial application made in the spring of 1973. There has been insufficient time to evaluate its effects. In view of precipitation of less than 14 inches annually, the effects of fertilizer on plant cover development may not be as great or as apparent or likely as in a more humid climate.

In summary, the short-term conclusions from rehabilitation efforts on this mine, which is representative of response unit 123-6-14, are: (1) Grading spoils to gentle slopes reduces erosion of the soil surface and greatly enhances contour farming techniques in rehabilitation; (2) native grasses--as well as some adapted introduced ones--establish and survive very well where the top 10 feet of overburden is used to finish off the spoil surface; (3) poorer but still satisfactory establishment of vegetation can be achieved where the deeper but still sandy overburden material is used for surfacing; (4) neither fertilizer nor watering has been necessary to establish vegetation on spoils at this mine; and (5) straw mulch disked into the spoils on the contour has greatly enhanced survival and subsequent plant growth.

5. *Bighorn Coal Co. (Bighorn)*.--This mine is near Sheridan, Wyoming, in rehabilitation-response unit 25-6-15. Overburden from the mine has been graded from level to grades of 2½:1. The top several feet of overburden is moderately fertile and stable. No severe surface erosion is evident. Rehabilitation work on this mine has been in progress since 1967. Planted were native grama grasses, needlegrasses, and wheatgrasses, as well as introduced crested wheatgrass. Native and introduced trees and shrubs were also planted. Rye has been an extremely successful nurse crop for new grasses. When planted in the spring, it sprouts in from 1 to 3 weeks. During the first year, it covers most of the soil and protects it against erosion. The Bighorn mine's Plachek plot, the first planted in 1967, supports a good stand of perennial grasses, as do all areas planted subsequently. Application of phosphorus and nitrogen fertilizer to newly regraded spoils finished off with topsoil is an excellent boost to new plant growth on this mine, as long as the soil is moist. Several tree species grow well in the area if irrigation water is available at the time of planting. Repeated watering during the first growing season enables newly planted trees to establish adequate root systems. The survival rate is substantially reduced in the absence of water.

The Bighorn mine encroaches upon the Tongue River, where the river has cut through a series of steep hills. Part of the area has been reshaped to create a lake fed by the Tongue River. Peter Kiewits Construction Co., owner of the mine, and the Wyoming State Parks Department coordinated this reclamation and rehabilitation effort. A State Park will be finished at about the same time that mining is completed. Conclusions drawn from 6 years of rehabilitation efforts at this mine are (1) a nurse crop of rye provides quick protection against surface soil erosion and enhances establishment of perennial vegetation; (2) good stands of perennial grasses and a variety of trees and shrubs can usually be established on this rehabilitation-response unit; (3) establishment of grasses does not require supplemental irrigation, but better survival of trees and shrubs depends on periodic watering during the first year. Fertilizing, especially with phosphorus and nitrogen, improves the rate of plant growth while the soil is still moist.

11. *Decker Coal Co. (Decker).*--This mine is at Decker, Montana, in rehabilitation-response unit 117-6-15. Soils at the Decker mine contain excess soluble salts and exchangeable sodium. Surface evaporation has drawn sodium salts to the surface. Most vegetation in the area, including blue grama grass, needlegrass, and western wheatgrass, are drought-, saline-, and alkaline-tolerant species.

Surface soil was removed and stockpiled separately from the main overburden piles. After mining, the overburden piles were regraded to a level or gentle slope, not exceeding 5:1, and finished off with topsoil. After mining, the configuration of the landscape is similar to that before mining. In most places, conventional farm machinery could be used for mine-rehabilitation activities.

Rehabilitation research at the Decker mine was begun in 1971 by the Montana Agricultural Experiment Station. Initially, the major emphasis was placed on overburden analysis to evaluate the seriousness of the saline-alkaline problem. More than 70 plant species were seeded. In the fall of 1972, the Intermountain Forest and Range Experiment Station established a completely randomized block experiment on Decker mine spoils to test the effects of irrigation versus no irrigation, fertilizer versus no fertilizer, and mulch versus no mulch on three mixtures of all native, native and pasture, and all pasture grasses. No evaluation of the Montana Agricultural Experiment Station plantings is available. First-year results of the Intermountain Station's plantings indicate that the best native species are western wheatgrass and green needlegrass. The best responding introduced species are smooth brome, winter rye, and tall wheatgrass. Gypsum appears to mitigate the adverse effects of saline-alkaline soils on these plants. Mulching enhances early germination and survival by conserving soil moisture. Phosphorus-nitrogen fertilizer, mulch, and irrigation separately increased vegetative growth and production. Together, fertilizer, mulch, and irrigation resulted in even greater increases in production. Topsoiling, alone, produced good stands of vegetation, but not as good as those developed with mulch and fertilizer. At the end of the first growing season, European sage had survived and grown well; it was the best of the planted shrubs.

Short-term conclusions from rehabilitation-research efforts on this mine are that vegetation can be reestablished on rehabilitation-response unit 117-6-15. Results show that: (1) establishment of vegetation is likely to be fair to poor in the absence of mulching to conserve soil moisture, phosphorus and nitrogen to stimulate growth, and irrigation and gypsum to counteract the adverse physiological effects of large amounts of sodium; (2) introduced grass species produce the greatest volume during the first year, but native species produce surprisingly more than had been expected; and (3) more research time is needed on the Decker mine before the stability and permanency of planted vegetation can be evaluated.

12. *Westmoreland Resources (Sarpy Creek).*--This mine is a new one near Hardin, Montana, in rehabilitation-response unit 31-4-14. The area is gently sloping. Soil texture varies from medium to moderately coarse. Adequate topsoil is available to be stockpiled and used to cover spoil surfaces during rehabilitation. Native vegetation is typical of vegetation type 4, which consists of green needlegrass, western and blue bunch wheatgrasses, sideoats grama, needle-and-thread, Idaho fescue, skunkbush sumac, chokecherry, hawthorne, snowberry, and, on some areas, ponderosa pine.

Overburden analyses show no significant differences between raw spoil materials and surface materials in respect to either sodium or salinity hazard. At this writing (early 1974), 1973 fall plantings have not yet germinated and developed. No problem is apparent in soil toxicity, vegetative suitability, or precipitation characteristics that would prevent establishment of plant cover on this mine. The limiting factor is likely to be rather mediocre natural productivity of this soil.

13 & 14. *Peabody Coal Co. and Western Energy Co. (Colstrip).*--These two mines are located at Colstrip, Montana, in rehabilitation-response unit 31-12-16. Soil texture

varies from moderately fine to coarse. Vegetation typifies the mid-short grass prairie, but scattered stands of ponderosa pine occur. Surface soil materials are available on both mines in ample quantities to cover less desirable overburden materials.

Both Peabody and Western Energy Co. have cooperated extensively in a research program with the Montana Agricultural Experiment Station. Using different site-preparation methods, scientists from Montana State University have screened many species of grasses, shrubs, and trees for adaptability to conditions on these two mines. Two seams of coal are being mined at the Peabody site. During early mining activity, a toxic blue-gray shale between the seams was deposited on the surface, creating difficulties in establishing vegetation. Mining techniques have since been changed to correct this situation. Rehabilitation research has been underway longer at Colstrip than at any other site in Montana. Short-term (3-year) results indicate that successful rehabilitation of response unit 31-12-16 with a variety of grasses, shrubs, and trees is highly probable. The most limiting major factor is the inherent mediocre productivity of soil association 31.

15. *Knife River Coal Co. (Savage)*.--This mine, near Savage, Montana, is on rehabilitation-response unit 26-5-13. Topography is gently sloping with shallow-to-deep, well-drained soils. Texture of the soil is loam to sandy loam. Topsoil materials range up to 2 feet in thickness and--if stockpiled--are adequate for finishing graded spoils during reclamation. Similarly, the sandy, yellowish-brown silt loam, and fine sandy loam material of the overburden beneath the topsoil are satisfactory for finishing graded spoil surfaces. Gray clay or silty clay above and between the coal seams are toxic and should be buried during the mining operation. Native vegetation is mid-grass prairie, mostly western and slender wheatgrasses, green needlegrass, and prairie sand reed.

Several years ago, the Knife River Coal Co. began grading old spoils to a gentle grade and planting them. The company has cooperated with the Montana Agricultural Experiment Station and the Soil Conservation Service in several experimental plantings. Excellent stands of both introduced and native grasses have been obtained, and several species of trees have been established successfully. This success was obtained on spoils that were leveled to 3:1 slopes. Standard seeding and planting techniques and commonly available plant materials were used. Much of this success can be attributed to the good productivity and stability characteristics of soil association 26, as well as to the rich and vigorous flora of the mid-grass prairie.

20. *Baukal-Noonan (Center)*.--This mine is a few miles southeast of Center, North Dakota, on rehabilitation-response unit 35-5-16. The terrain is rolling, the soil is loamy, and the overburden is sandy and shaley. Spoils on this mine have been unusually well shaped and blended into the natural landscape.

Research has shown that the overburden on lignite coal deposits, which characterize most of North Dakota, contains substantially higher quantities of sodium than does the overburden on the sub-bituminous coal deposits in eastern Montana and northeastern Wyoming (Sandoval and others 1973). This difference has given rise to more serious sodium-toxicity problems in connection with rehabilitation efforts on surface mines in North Dakota than has been experienced on most mines in Montana or Wyoming. Whereas sodium content of overburden from Baukal-Noonan's (Center) North Dakota mine is somewhat higher than that encountered on the Montana and Wyoming mines, it is still substantially less than that on any other major North Dakota mine. Accordingly, overburden on this mine forms a relatively favorable planting medium, limited only by the rather mediocre inherent productivity of soil association 35. A variety of cool-season grasses and legumes have been planted on this mine, including western wheatgrass, big and little bluestem, sweet clover, and crown vetch. Success of various plantings, including those areas drilled in the fall of 1972, is generally good. This soil association has poor stability characteristics, and deep rilling has occurred where spoil slopes were too steep for cross-slope finish work. Where spoils have been drilled upslope and downslope, a high erosion hazard exists. Level or gentle slopes and cross-slope cultivation appear to be essential for permanently stable reclamation of this rehabilitation-response unit.

21. *North American Coal Co. (Zap)*.--This mine, near Zap, North Dakota, is on rehabilitation-response unit 35-5-16. Overburden, which resulted from mining here, has been shown to have the second highest average sodium content of eight major mines sampled in North Dakota. Spoils from this mine have the highest sodium-adsorption ratio and pH of any mine for which records are available in the Northern Great Plains (Sandoval and others 1973). The fine-textured spoil materials consist largely of montmorillonitic clay, are low in natural organic matter, and are highly toxic to vegetation.

Overburden from this mine, except that within approximately 10 feet of the original surface, presents a tremendous rehabilitation problem if placed on the surface of graded spoils. Analyses of North Dakota overburden by depth increments indicate that the sodic nature of the spoils increases with depth within the feasible depth range for surface mining. Experience on this mine indicates that, over a period of several years, adsorbed sodium in the mine spoils can be reduced by a chemical amendment (gypsum) or circumvented by a surface layer of soil. Little success has been achieved in rehabilitating raw spoils originating from deep, sodic layers. The dispersing effect of sodium renders the spoil material highly impermeable and erodible.

Where graded spoils have been finished off with overburden from shallow depths, immediately fertilized with phosphorus, treated within 2 years with nitrogen, together with vegetative mulch disked into the spoil surface, grass production has increased as much as 1,000 percent compared to the production on raw spoils.

On this mine and others that have similar adverse spoil characteristics, further research is needed to overcome toxicity problems before these spoils can be successfully and directly rehabilitated. Where shallow nontoxic overburden or surface soil can be used to finish spoil surfaces, immediate and successful rehabilitation to midgrass prairie or, in some cases, to cultivated grain crops, can be achieved.

22. *Knife River Coal Co. (Beulah)*.--This mine is near Beulah, North Dakota, in rehabilitation-response unit 23-5-16. Overburden materials on this mine have essentially the same sodium and pH characteristics as those in overburden on the North American mine at Zap. Little real success has been experienced in attempts to rehabilitate raw surface spoils originating from deep levels in this mine. On the other hand, attempts to rehabilitate spoils from within approximately 10 feet of ground surface or spoils dressed with surface soil by using both introduced and native grasses and legumes have been successful. One reason for this success is the inherent good stability and productivity characteristics of soil association 23.

23. *Consolidation Coal Co. (Glenharold)*.--This mine, near Stanton, North Dakota, is in rehabilitation-response unit 35-5-16. The soil, native vegetation, and precipitation characteristics of this mine are similar to the North American mine at Zap; however, the terrain is considerably more steep and hilly. Soils are loamy, but shallower because of the steeper topography. Overburden is dominantly grayish-white, and the surface dries hard after being wet, indications of high-sodium content. Tests of overburden at this mine confirm that the sodium content is toxically high, although not as high as in the Knife River mine at Beulah or in the North American mine at Zap (Sandoval and others 1973). Soil association 35 has poor stability characteristics; these are reflected on the steeper spoil slopes where rilling and gullying have occurred.

Where overburden from shallow depths or topsoil has been used to finish the surface of graded spoils, good rehabilitation results have been achieved. Mined areas are now being graded to gentle slopes, disked, and seeded to native cool-season grasses. The Consolidation Coal Co. has treated about 80 acres of raw spoils in this manner.

They have replaced topsoil on a smaller acreage and grown wheat. The company and the Soil Conservation Service have planted a variety of shrubs and trees, to evaluate their suitability for use in rehabilitating these kinds of areas. Species being tested include Russian olive, caragana, and prairie rose. About 90 percent of these species have survived. Where problems associated with high-sodium spoils have been circumvented, vegetation has become so well established that many areas appear to be undisturbed.

24. *Baukal-Noonan (Noonan Strip)*.--This mine is near Larsen, North Dakota, in rehabilitation-response unit 19-9-15. Coal from deep levels of this mine has the highest sodium content of any sampled in North Dakota (Sondreal and others 1968); consequently, it is postulated that the adjacent overburden is also high in sodium and is probably toxic for rehabilitation purposes when left on the surface of graded spoils. Surface soil from soil association 19 on this mine has good stability and productivity. Rehabilitation experience here is similar to that already noted on other North Dakota mines: little success on raw spoils from deep levels; more success on spoils from shallow depths; and most success where surface soil has been removed and then replaced as a finish for graded spoils.

25. *Consolidation Coal Co. (Velva)*.--This mine is near Velva, North Dakota, in rehabilitation-response unit 19-9-16. Tests on 10 major surface mines in the Northern Great Plains indicate that although the average sodium content of overburden from this mine is substantially greater than that in the Montana-Wyoming area, it is still only about half the sodium content encountered on most surface mines in North Dakota (Sandoval and others 1973). Spoils on this mine have been graded to gentle slopes. The soil is stable, and regraded spoils show little erosion. Rehabilitation success has not been good on raw spoils originating from deep overburden. However, rehabilitation efforts on shallow overburden materials or on surface soil-dressed spoil areas seeded with wheatgrasses, bluestems, and legumes have been successful.

26. *Knife River Coal Co. (Gascoyne)*.--This surface mine is at Gascoyne, North Dakota, in rehabilitation-response unit 25-5-15. Surface soils in this rehabilitation-response unit and on this mine are productive and stable. The soil is loamy and the terrain is level to gently rolling. Coal is at a relatively shallow depth, which necessitates removal of less than 50 feet of overburden. Sodium should not present a serious problem. Accordingly, tests show that the average sodium content is less than that from any other North Dakota mine tested (Sondreal and others 1968). The Knife River Co. began reclamation work in 1971. Some spoils have been reshaped to undulating topography. Cool-season grasses have been seeded and are establishing successfully.

29. *International Minerals and Chemical Co.;*

30. *American Barroid Co.;* and

31. *Federal Minerals Co. (Alzada, Montana)*.--

These three bentonite mines are located in rehabilitation-response unit 111-5-14. The topography is nearly level to gently sloping. Soil texture varies from claypan spots to sandy loams. Little weathering or soil development has occurred on pan spots, and surface materials for reclamation are not available from these sites. Most of the area has medium-textured soils supporting a good cover of western wheatgrass, needle-and-thread, prairie sand reed, and other desirable species. Some bur oaks occur on these sites. Such sites can provide weathered soil material necessary for reclaiming mined areas. Reclamation activities on these mines include the placement of about 4 inches of surface soil over all disturbed areas. This has been sufficient to support good seeded stands of grasses, mostly western wheatgrass, green needlegrass, and crested wheatgrass. The raw overburden is usually composed of saline clays, and stands do not become well established unless these materials are dressed with surface soil. The companies in this area have been cooperating with the Soil Conservation Service Plant Materials program to evaluate a variety of plant materials for possible use in revegetating mine spoils.

IMPACTS OF DEVELOPMENT OF THE COAL RESOURCE ON SURFACE REHABILITATION

To this point, this report has been concerned with descriptions of soil associations, vegetation types, and precipitation characteristics that combine to delineate different rehabilitation-response units on the surface mineable lands of the Northern Great Plains. The remainder of the report analyzes and summarizes the degree of potential success that might be expected in attempting to reclaim and revegetate different rehabilitation-response units.

Rating Criteria for Ranking Response Units According to Their Rehabilitation Potentials

Ranking of rehabilitation-response units according to their rehabilitation potentials depends upon combined ratings of soil productivity and stability, vegetation suitability and availability for rehabilitation, and amount and distribution of annual precipitation. Each of these soil, vegetation, and precipitation characteristics was rated on a descriptive-numerical scale as follows: very good (+9), good (+6), fairly good (+3), fair (0), fairly poor (-3), poor (-6), and very poor (-9).

Soil association productivity and stability ratings.--The productivity and stability of each surface mineable soil association in the Northern Great Plains was rated by means of the scale described above. Information concerning the productivity and stability of the soil associations was obtained from Aandahl's (1972) description of soil associations of the Northern Great Plains. These ratings are shown in table 8. Also presented is a combined rating for each soil association, obtained by averaging productivity and stability ratings. These combined ratings show that soil associations 19 and 25 (each rated +8) are the most productive and stable of these soil associations. Combined ratings also show that soil association 123 (rated -8) and soil associations 121 and 184 (each rated -9) are the least productive and most erodible of the 17 soil associations.

Vegetation type suitability and availability ratings.--The suitability of major native plant species in each of the nine surface mineable vegetation types and their availability for rehabilitation purposes were also rated. These two ratings were averaged to provide a single combined suitability-availability rating of major species for rehabilitation in each of these vegetation types. These ratings are presented in table 9. They show that the mid-tall grass prairie has the most suitable and available plant species for successful rehabilitation. They also indicate that the Badlands offer the poorest chance for rehabilitation; however, with the exception of the Badlands, all vegetation types contain some plant species that are suitable and available for rehabilitation purposes.

Table 8.--*Relative ranking of soil associations in terms of productivity and stability*

Soil association No.	Productivity rating	Stability rating	Combined rating
19	+6	+9	+8
23	+6	+6	+6
25	+9	+6	+8
26	+6	+6	+6
27	+3	+3	+3
30	+3	+3	+3
31	0	-6	-3
33	0	-6	-3
34	0	-6	-3
35	0	-9	-5
44	-3	-3	-3
109	-9	0	-5
111	-6	-3	-5
117	-6	0	-3
121	-9	-9	-9
123	-9	-6	-8
184	-9	-9	-9

Table 9.--*Relative ranking of vegetation types in terms of suitability and availability of plant species for rehabilitation*

Vegetation type	Type No.	Suitability rating	Availability rating	Combined rating
Floodplain	1	-6	-3	-5
Badlands	2	-9	-9	-9
Short grass prairie	3	-3	0	-2
Mid-short grass prairie	4	-3	0	-2
Midgrass prairie	5	0	+6	+3
Grassland-sagebrush	6	+6	+3	+5
Sagebrush steppe	7	+3	-3	0
Mid-tall grass prairie	9	+9	+9	+9
Ponderosa pine forest	12	0	+6	+3

Precipitation amount and seasonal distribution ratings.--The amount and seasonal distribution of annual precipitation on surface mineable lands of the Northern Great Plains were rated by means of the descriptive-numerical rating scale. These two ratings were averaged to provide a combined precipitation rating. In table 10, as might be expected, these ratings show that areas that have more than 16 inches of annual precipitation have the best potentials for rehabilitation; those areas that have less than 12 inches have the poorest potentials.

Table 10.--*Relative ranking of precipitation zones in terms of annual amounts and seasonal distribution*

Precipitation zone	Amount rating	Distribution rating	Combined rating
<12	-9	-9	-9
12	-6	-6	-6
13	-3	-3	-3
14	0	0	0
15	+3	+3	+3
16	+6	+6	+6
>16	+9	+9	+9

Rehabilitation Potential Rankings of Response Units

Combined ratings of soil, vegetation, and precipitation characteristics must be translated into one rehabilitation-potential ranking for each kind of rehabilitation-response unit on surface mineable lands in the Northern Great Plains; consequently, the combined rating values of the appropriate soil association (table 8), vegetation type (table 9), and precipitation zone (table 10) comprising each rehabilitation-response unit were added together algebraically and averaged. This process provided a ranking number for each rehabilitation-response unit that had a potential value of from +9 to -9. These ranking numbers indicate *the relative degree of ease or difficulty* (potential) that should be anticipated in attempting to rehabilitate *a unit area* of surface-mined land of given soil, native vegetation, and precipitation characteristics. These ranking values for all response units range from +6 to -5, an indication that none of the rehabilitation-response units exhibits either the best or the worst potential for rehabilitation.

The total area of each kind of rehabilitation-response unit in each State and county of the Northern Great Plains coal province is shown in table 4. The area of each kind of rehabilitation-response unit to be mined in each of five sample areas was calculated from the tonnage production figures determined for each of three coal development forecasts during three time frames.[2]

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[2] Unpublished report of the Northern Great Plains Resource Study, U.S. Dep. Interior. The three coal resource development forecasts assumed in this report are (1) base forecast, which is continued development of the coal resource, including coal for exports and energy-conversion facilities, at about the same rate as prevailed in 1972; (2) most probable forecast, which is development at a rate several times greater than that of the base forecast; and (3) extensive forecast, which is development at the highest rate that is physically and economically feasible. The three time frames are the periods 1972 to 1980, 1980 to 1985, and 1985 to 2000.

Table 11.--*Rehabilitation potential rankings weighted by areas that will be surface mined under each of three forecasts of development of the coal resource and three time frames*[1]

Coal resource development forecast	By the year	Campbell County	Bighorn County	Rosebud County	Mercer-Oliver Counties	All other counties	Northern Great Plains total
Base	1980	+48	+192	+1,086	+5,483	0	+6,809
	1985	-2,712	+1,252	+2,781	+10,663	+4,155	+16,139
	2000	-10,991	+4,432	+7,866	+26,203	+17,820	+45,330
Most probable	1980	+48	+192	+1,086	+5,483	0	+6,809
	1985	-2,712	+2,280	+2,781	+10,663	+4,155	+17,167
	2000	-18,881	+14,355	+19,491	+36,808	+64,230	+116,003
Extensive	1980	+48	+192	+1,086	+5,483	0	+6,809
	1985	-2,409	+3,200	+4,176	+31,873	+34,375	+71,215
	2000	-28,283	+25,400	+52,506	+121,148	+207,385	+378,156

[1] Degree ratings X area mined.

Table 12.--*Surface-mined areas that will require rehabilitation under each of three forecasts of development of the coal resource and three time frames*

Coal resource development forecast	By the year	Campbell County	Bighorn County	Rosebud County	Mercer-Oliver Counties	All other counties	Northern Great Plains total
		Acres					
Base	1980	56	96	1,605	2,599	0	4,356
	1985	2,036	1,276	4,900	5,999	900	15,111
	2000	7,977	4,816	14,785	16,199	3,840	47,617
Most probable	1980	56	96	1,605	2,599	0	4,356
	1985	2,341	1,533	4,900	5,999	900	15,673
	2000	12,287	9,018	22,690	26,804	18,330	89,129
Extensive	1980	56	96	1,605	2,599	0	4,356
	1985	2,341	1,993	6,295	13,069	8,870	32,568
	2000	25,890	13,528	43,975	54,584	57,110	195,087

Table 13.--*Average weighted rehabilitation-potential rankings for each of three forecasts of development of the coal resource and three time frames*

Coal resource development forecast	By the year	Campbell County	Bighorn County	Rosebud County	Mercer-Oliver Counties	All other counties	Northern Great Plains total
Base	1980	+0.86	+2.00	+0.68	+2.11	--	+1.56
	1985	-1.33	+0.98	+0.57	+1.78	+4.62	+1.07
	2000	-1.38	+0.92	+0.53	+1.62	+4.64	+0.95
Most probable	1980	+0.86	+2.00	+0.68	+2.11	--	+1.56
	1985	-1.16	+1.49	+0.57	+1.78	+4.62	+1.10
	2000	-1.54	+1.59	+0.86	+1.37	+3.50	+1.30
Extensive	1980	+0.86	+2.00	+0.68	+2.11	--	+1.56
	1985	-1.03	+1.61	+0.66	+2.44	+3.88	+2.19
	2000	-1.09	+1.88	+1.19	+2.22	+3.63	+1.94

The area value and rehabilitation-potential ranking value of each rehabilitation-response unit were multiplied together for each of the three time frames within each of the three coal forecasts. Essentially, this means that rankings, which indicate the relative potential for rehabilitating a unit area of a given response unit, have been weighted by areas (acres that need to be mined to meet the coal production requirements of each forecast). The algebraic totals of these weighted rankings are summarized in table 11. For purposes of comparison, only surface-mined area values are listed in table 12. Finally, the weighted rankings (table 11) are divided by the area-mined values (table 12), which provides the *average* weighted rehabilitation-potential rankings of the five sample areas for each coal-development forecast and each time frame. These average weighted rehabilitation-potential rankings are summaried in table 13.

Implications of Response Unit Rankings for Rehabilitation of Surface Mines in the Sample Counties and Other Areas

Inspection of the rehabilitation-potential rankings weighted by areas that will be surface mined (table 11) reveals that rehabilitation-response units that characterize Mercer and Oliver Counties in North Dakota collectively have a much higher potential for successful rehabilitation than do those in the other sample counties; soils are more productive, vegetation types more suitable, and precipitation higher in Mercer and Oliver Counties than in the other sample areas. The weighted rehabilitation-potential rankings (table 11) also show that Rosebud County, Montana, has the next best potential for successful rehabilitation, followed by Bighorn County, Montana, and Campbell County, Wyoming. The poorest rehabilitation potential, recorded for Campbell County, results from a combination of poorly productive soils, vegetation types that have fewest suitable and available species, and the lowest precipitation in the Northern Great Plains coal province. Those areas of the Northern Great Plains coal province (All other counties, tables 11, 12, and 13) outside the boundaries of sample counties exhibit rehabilitation-potential rankings nearly as good and, in some cases, better than those of Mercer and Oliver Counties.

As might be expected, the rehabilitation-potential rankings (table 11) become larger in either a positive or negative direction as the coal-development forecast shifts from base to most probable to extended (see footnote 1). An exception occurs up to the year 1980 because the kinds of rehabilitation-response units and the areas thereof to be mined in that time frame are the same for all three development forecasts.

Table 12 reveals that the surface-mined areas requiring rehabilitation will increase as coal development shifts from base to most probable to extended and as the time frame moves from year 1980 to 1985 to 2000. In themselves, these increases in acreages to be mined imply an increasingly larger rehabilitation job, regardless of location.

The average weighted rehabilitation-potential rankings are presented in table 13. These values reveal information similar to that in table 11; however, the masking effect caused by differences in the areas to be mined has been removed. Values in table 13 reveal several kinds of important information:

1. Throughout the Northern Great Plains coal province, and especially in the sample counties, the average potential for successfully rehabilitating surface-mined lands increases with a shift from base to most probable to extensive coal-development forecasts. Accordingly, as the intensity of surface mining increases, progressively more mining will be done on rehabilitation-response units that have high rehabilitation potential rankings than will be done on those that have low ones. In the remainder of the region, the average weighted rehabilitation-potential rankings decrease

with intensification of mining activity. This decrease indicates that with intensified development of the coal resource in these areas, progressively more response units of low rehabilitation potential will be mined. Nevertheless, even with intensified development, average potentials for rehabilitation in these areas are higher than in any of the sample county areas.

2.--The highest average weighted rehabilitation-potential rankings occur on regional areas outside sample county areas. The Mercer and Oliver County areas have the highest rankings of the sample counties, followed in decreasing order by Bighorn, Rosebud, and Campbell Counties. The lowest rehabilitation-potential rankings, which average out to be negative values, occur in Campbell County.

3.--Within the base-development forecast, each sample county exhibits a decrease in average rehabilitation-potential rankings as the time frame shifts from 1980 to 1985 to 2000. In other words, the moderate increase in mining intensity associated with the changing time frame in the base-development forecast will result in the mining of a higher proportion of rehabilitation-response units of low rehabilitation potentials. Except for sample counties, virtually no mining development is scheduled prior to 1980, and the average rehabilitation-potential rankings are about the same for 1985 and 2000.

4.--Within the most probable development forecast, a decrease in the average rehabilitation-potential ranking of each sample county occurs between 1980 and 1985. Essentially, this decrease is similar to that occurring over the same time frame in the base-development forecast. However, between the years 1985 and 2000, a further continued decrease in the average rehabilitation-potential rankings occurs only in Campbell, Mercer, and Oliver Counties, and in regional areas outside sample counties. In Bighorn and Rosebud Counties, average rehabilitation-potential rankings based on the most probable development forecast, will increase from 1985 to 2000. This increase indicates that current scheduling of mining activities in these two counties includes more rehabilitation-response units of high-rehabilitation potential than of low.

5.--Within the extensive development forecast, the average rehabilitation-potential ranking for Campbell County decreased throughout the three time frames. In Bighorn and Rosebud Counties, rehabilitation-potential rankings decreased from 1980 to 1985, but increased again between 1985 and 2000. On the other hand, rehabilitation rankings for Mercer and Oliver Counties increased from 1980 to 1985, but decreased between 1985 and 2000. Although rehabilitation-potential rankings for regional areas outside sample counties were the highest in the entire study area, they decreased between 1985 and 2000. These increases and decreases in rehabilitation-potential rankings indicate differences in relative ease of rehabilitating surface-mined lands. Differences result from the sequential order in which rehabilitation-response units of better-than-average and poorer-than-average potentials for rehabilitation are scheduled for mining. Comparisons such as have been made here could be utilized to restructure the development forecasts. Such restructuring could establish a more uniform distribution of rehabilitation potentials with respect to time; and, hence, a more uniform rehabilitation effort throughout any coal-development period for any given portion of the Northern Great Plains.

Comparison of Rehabilitation-Potential Rankings From Actual Rehabilitation Efforts and From Classification of Response Units

Table 7 lists 16 coal and 3 bentonite mines for which descriptive information exists as to relative success of past rehabilitation efforts. Accordingly, descriptive rankings of *actual* rehabilitation success at these mines were compared with the rehabilitation-potential rankings of the response units in which these mines are located (table 14). The numerical equivalents of the descriptive rankings of actual rehabilitation success on these mines were compared with the rankings of rehabilitation-response units. Comparisons reveal that the rankings of potential-rehabilitation ease on the rehabilitation-response units in which the mines are located are probably somewhat conservative. They indicate a rehabilitation-potential ranking slightly lower than the ranking of actual rehabilitation success achieved on these mines. Notwithstanding, this sample of 19 mines (some of which have been subjected to rehabilitation efforts for only a short time) is sufficiently small that alteration of the predicted rehabilitation-potential rankings to conform to the actual rehabilitation success rankings is not yet warranted. Furthermore, with few exceptions, predictive rankings are close enough to actual rankings that they can be used conservatively with confidence.

Table 14.--*Comparison of rehabilitation potential rankings from actual rehabilitation efforts and from classification of rehabilitation-response units*

Mine No.	Mining company and mine	Rehabilitation-response unit	Rehabilitation potentials		
			From actual rehabilitation		From classification rankings
			Descriptive	Numerical	Numerical
		COAL OPERATIONS			
1	Wyodak Resources Development Co. (Wyodak)	117-6-14	Good	+6	+1
2	AMAX Coal Co. (Belle Ayr)	117-6-13	Fairly good	+3	0
4	Pacific Power & Light Co. (Glenrock)	126-6-14	Fairly good	+3	-1
5	Bighorn Coal Co. (Bighorn)	25-6-15	Good	+6	+5
11	Decker Coal Co. (Decker)	117-6-15	Fairly good	+3	+2
12	Westmoreland Coal Co. (Sarpy Creek)	31-4-14	Fairly poor	-3	-2
13	Peabody Coal Co. (Colstrip)	31-12-16	Fairly good	+3	+2
14	Western Energy Co. (Colstrip)	31-12-16	Fairly good	+3	+2
15	Knife River Coal Co. (Savage)	26-5-13	Good	+6	+2
20	Baukal-Noonan Co. (Center)	35-5-16	Fairly good	+3	+1
21	North American Coal Co. (Zap)	35-5-16	Fairly good	+3	+1
22	Knife River Coal Co. (Beulah)	23-5-16	Good	+6	+5
23	Consolidation Coal Co. (Stanton)	35-5-16	Fairly good	+3	+1
24	Baukal-Noonan Co. (Noonan Strip)	19-9-15	Very good	+9	+7
25	Consolidation Coal Co. (Velva)	19-9-16	Very good	+9	+8
26	Knife River Coal Co. (Gascoyne)	25-5-15	Good	+6	+5
		BENTONITE OPERATIONS			
29	International Minerals & Chemical Co. (Carter)	111-5-14	Fair	0	-1
30	American Barroid Co. (Carter)	111-5-14	Fair	0	-1
31	Federal Minerals Co. (Carter)	111-5-14	Fair	0	-1

CONSTRAINTS AND LIMITATIONS ON REHABILITATION

Relatively little experimentation and research have been directed to the problem of rehabilitating lands being mined for coal in the Northern Great Plains. Whereas much is known about revegetating western rangelands, comparatively little is known about rehabilitation of mine spoils. Actual rehabilitation efforts have been applied on relatively few mine sites. Perhaps the most important single point emerging from this study of surface-rehabilitation potentials is that the potential for rehabilitating surface-mined land in the Northern Great Plains is extremely site specific. The general rehabilitation potential can be judged on the basis of climatic, soil, and vegetative site components, but each site will also have its particular microclimate in terms of specific physiographic, biotic, and hydrologic components. These components influence the potential for rehabilitation of a specific site. Finally, what is done and how a site is prepared for rehabilitation also influence the rehabilitation potential. These macrosite and microsite components, as well as the measures employed to effect rehabilitation, inherently impose constraints and limitations on the rehabilitation of some sites. A brief summary of constraints on and limitations to successful rehabilitation of surface-mined sites in the Northern Great Plains follows:

1. *Macroclimate.*--Without question, local climate is the most important single parameter in assessing potential-rehabilitation success. Furthermore, the most important single climatic element influencing this success is the amount and distribution of precipitation. Assuming that approximately 10 inches of annual precipitation is the minimum amount of water needed to sustain revegetation, most surface-mined sites that receive 10 inches or less annual precipitation cannot be mapped accurately; adequate precipitation records are lacking for most such mining sites, and the nearest weather station may be many miles removed.

Variation of the annual precipitation about the mean is extremely important to revegetation success. Droughts severe enough to almost wreck the range livestock industry in the Northern Great Plains have occurred and, no doubt, will occur again. Potentials for successful rehabilitation during such droughts would be far less than those during years of average or above-average precipitation. Little site-specific analytical work has been done on precipitation variation in the Northern Great Plains.

2. *Microclimate.*--Most surface mineable lands in the Northern Great Plains are characterized by relatively gentle topography. In many instances, spoil piles left after mining constitute rougher topography than existed before mining. The configurations into which such spoil piles are shaped by heavy grading machinery can substantially influence the microclimate of each surface-mined site. Steepness of slope, roughness of surface, and direction of aspect in respect to insolation and wind can all be affected by the land-reshaping plans and measures employed.

3. *Availability of suitable plant materials.*--The author of this report assumes that unless some other rehabilitation objective is defined, the primary objective of rehabilitation on surface-mined lands in the Northern Great Plains is to establish a protective cover of durable plants, predominantly native species adapted to and characteristic of these areas before mining. Accordingly, tall-, mid-, and short-grass prairie species, some shrubs, and a few trees are the plants chiefly used to rehabilitate these surface-mined lands. Surface mineable lands in the North Dakota portion of the study area are characterized by a rich mixture of tall- and mid-grass prairie species, the seeds of which usually are commercially available in quantity. The drier portions of the study area, which are in northeastern Wyoming and eastern Montana, are characterized by short-grass prairie species that sometimes occur with dryland shrubs. These short grasses are not nearly as available commercially as are species in moister parts of the study area. A supply of seeds from these dryland species must be developed if they are to be available in sufficient quantities for rehabilitation of lands to be surface mined.

4. *Site and seedbed preparation.*--More than a half century of range revegetation and farming experience in the Northern Great Plains has resulted in development of site- and seedbed-preparation techniques that can be used successfully to revegetate disturbed landscapes. Minimum requirements would certainly include grading of spoils to short lengths of gentle-to-moderate slopes and placement of the highest site-productive overburden strata on the surface. Equally essential is the tillage accomplished by established agricultural procedures of spoil surface materials to a satisfactory condition for seeding and planting. Failure to shape and till the land satisfactorily can result in greatly reduced rehabilitation success or in complete failure.

5. *Planting procedures.*--Suitable planting procedures that provide for seed coverage by surface spoil materials at the proper depths is essential for successful revegetation of surface-mined land. Seeds cannot simply be thrown upon bare ground without application of planting technology. Many years of range revegetation and farming experience in the Northern Great Plains have identified planting procedures crucial for successful reestablishment of vegetation. Among these are the best methods for seeding and planting, the best methods and depths for covering different kinds of planted seeds, the best season to plant in each geographical locality, and the best kinds of mulch and methods of application to increase seed germination and seedling survival. Failure to apply all steps of the best planting procedures carefully can only result in reduced revegetation success.

6. *Fertilizers and soil amendments.*--As indicated earlier, the soils in Wyoming and Montana that characterize the western portion of the Northern Great Plains coal province are deficient in phosphorus. Similarly, the soils that characterize the eastern portion, mostly in North Dakota, exhibit nitrogen deficiencies. Despite these generalities, information is needed about the fertility regime of the surface several feet of mine spoils destined for revegetation. Fertilizers that supply nutrient deficiencies in these spoils must be applied for best revegetation success.

Spoil bank materials in the Northern Great Plains are nearly always alkaline. Most have a high saturation-percentage value, which stems from high clay content and cation composition. A high saturation-percentage value explains why many subsoils exposed by strip mining are relatively high in salinity. This situation can often be corrected (e.g., by adding gypsum) provided sufficient planning and effort have identified saline surface spoils and the magnitude of salinity involved. Every effort should be made to bury spoils that have toxic saline levels.

7. *Irrigation.*--Erratic climatic conditions, especially in the amounts and distribution of precipitation, remain the dominant factor in success or failure of revegetation efforts on surface-mined sites carved from semiarid rangeland ecosystems. Accordingly, addition of irrigation water is sometimes desirable and even necessary to the establishment and survival of seedlings. Many subsurface and some surface water supplies have high sodium contents. Accordingly, newly planted mine spoils must be carefully and frequently irrigated, in association with the use of soil amendments, to avoid the development of unfavorable saline conditions.

8. *Spoil surface stabilization.*--As indicated, some spoil materials in the Northern Great Plains are fairly resistant to erosion by water and wind, whereas others are not. In general, the most highly erodible spoils, which usually contain more sodium on clays, occur in the North Dakota portion of the Northern Great Plains. This area also receives the most rainfall. Generally speaking, these two conditions combine to produce the heaviest overland flow and surface soil erosion on mine spoils. Under such conditions, it is desirable, probably necessary, to prevent or control surface instability if vegetation is to be established. Prevention or reduction of surface runoff and soil erosion from mine spoils can be achieved by a combination of measures, including grading to gentle slopes, terracing, pitting, and mulching. Failure to stabilize spoil surfaces against raindrop and runoff impacts prior to establishment of vegetation usually results in a high degree of rehabilitation failure.

9. *Post-rehabilitation care.*--Rehabilitation of such drastically disturbed sites as surface mine spoils is somewhat similar to planting and landscaping the yard of one's newly built home. It would be unthinkable to carefully plant a lawn, shrubs, trees, and flowerbeds and then to leave the plantings without further attention. It should be equally unthinkable to do everything necessary to insure successful rehabilitation of mine spoils, and then to forfeit the entire effort for lack of necessary subsequent care. In other words, the land must be managed during and after rehabilitation. When necessary, management involves measures to control destruction of new vegetation by insects, rodents, livestock, and big game. Measures may include fencing or the use of repellents to prevent or discourage damage from such sources.

10. *Rehabilitation time frames.*--The length of time required to successfully rehabilitate surface-mined sites depends upon essentially the same environmental factors that determine rehabilitation potentials. In other words, each kind of response unit probably has its own characteristic period required for successful rehabilitation under specified treatment. By assuming that response units of high potential rankings can be rehabilitated faster than those with low rankings and by considering the nature of revegetated plant cover on surface mines of relatively recent vintage, it is possible to speculate with some degree of reason about rehabilitation time frames. The author believes that the higher rated response units, which occur predominantly in North Dakota, can be rehabilitated successfully in from 1 to 5 years, depending upon whether the rehabilitation objective is agricultural cropland or mixed-grass range. On the medium-rated response units that dominate the moister areas of southeastern Montana and northeastern Wyoming, successful rehabilitation should be achieved in from 5 to 10 years, depending upon whether the rehabilitation objective is to return the land to short-grass prairie, a grass-shrub steppe, or a mixture of these types and ponderosa pine. On the lower-rated response units in the drier portions of northeastern Wyoming and northeastern Montana, from 5 to 15 years may be required to successfully return the land to the short-grass and/or shrub-steppe range that characterized it prior to mining.

During several consecutive years of above-normal precipitation, these time frames, particularly the longer ones, might be shortened substantially. On the other hand, during several consecutive years of drought, these time frames, especially the short ones, might be lengthened. No doubt, careful irrigation and fertilizing for the first several growing seasons would effectively shorten the time required to achieve successful rehabilitation.

11. *Rehabilitation objectives*.--In the Northern Great Plains, relatively few alternative rehabilitation objectives are feasible. Gentle topography, paucity of water, and lack of broad-scale variability in vegetation growth forms combine to limit feasible alternatives for rehabilitation objectives. The following objectives are not all inclusive, but they probably come close to delineating the feasible rehabilitation alternatives available in the Northern Great Plains:

a.--Return as nearly as possible to original range/forest condition;

b.--Return to previous agricultural cropland condition;

c.--Convert from previous range/forest condition to agricultural cropland;

d.--Convert from previous agricultural cropland to range/forest condition;

e.--Take advantage of such specialized features as water for ponds or lakes to develop unique recreation and/or wildlife habitat areas; and

f.--Develop such intensified land uses as airports, industrial or residential areas, solar energy sites, etc.

COSTS OF REHABILITATION

Revegetation costs include those of shaping spoils, use of topsoil or other suitable strata, seedbed preparation, seeding, fertilizing, soil amendments, mulching and, sometimes, irrigation. Largest expenses are usually those of shaping the land and surfacing with suitable material. Most estimates of rehabilitation costs emphasize either per-acre or per-ton costs. A more realistic alternative is to base costs on the stripping ratio (the cost as a function of area disturbed relative to the coal produced). Thus, economic considerations favor surface mining where coal seams are thick and overburden is thin. In the Northern Great Plains coal province, the lowest operating costs and the least area of disturbance per million tons of coal produced occur in Wyoming and Montana where thick coal seams are covered by relatively thin overburden. In contrast, the highest operating costs and the greatest unit disturbance per million tons of coal mined are found in North Dakota where coal seams are thinner and are more deeply buried. The thickest coal seams, the thinnest overburden, and the smallest acreage mined per million tons of coal production occur in those parts of the Northern Great Plains that have the lowest rehabilitation potentials.

Conversely, the greatest acreages of mine disturbance per million tons of coal occur in those parts of the Northern Great Plains that have the highest rehabilitation potentials. At the time of this writing (1974), estimates of direct on-site rehabilitation costs in these coalfields range from approximately $700 to $1,800 per acre, depending upon the location and the problems encountered. Rehabilitation costs include those of land shaping, seedbed preparation, seeding, fertilizing, soil amendments, water control on slopes, mulching, sediment control in detention basins, shrub or tree planting, and soil surfacing. Considering the tonnages of coal that will be mined per acre in the Northern Great Plains, mining operations apparently can bear the full expense of rehabilitation without adding more than a few cents per ton to the price of coal.

LEGAL BASIS FOR ENFORCEMENT OF SURFACE-MINE REHABILITATION

On the basis of information contained in this report, the author concludes that virtually all surface-mined lands in the Northern Great Plains can be successfully rehabilitated, albeit some more easily than others. However, this conclusion requires some qualification. Even on those rehabilitation-response units that have the highest rehabilitation potentials, rehabilitation will be successful only when (1) planning both in mining and rehabilitation is adequate and (2) monitoring and enforcement of rehabilitation is diligent over a meaningful period. Fulfillment of these qualifications depends upon effectual laws and administration, which, in turn, implies coordinated efforts by local, State, and Federal Government agencies. The Congress of the United States is actively considering legislation to regulate surface mining; however, to date, no Federal law has been adopted for the specific purpose of rehabilitating lands disturbed by mining. For the most part, neither Federal nor local regulations are explicit as to surface mining and rehabilitation. On the other hand, all States represented within the Northern Great Plains coal province have explicit laws in this regard. A summary was made of State legal requirements regarding the rehabilitation of surface-mined lands in the Northern Great Plains coal province. The information reveals that none of the States have complete legal authority covering all major rehabilitation requirements. Wyoming and Montana laws appear to be the most encompassing in this respect. North Dakota's law is somewhat less strict and South Dakota's law appears to be least stringent. In only 4 of 18 rehabilitation activities do *all* States have specifications. These specifications pertain to grading and shaping spoils, providing surface drainage, surfacing of spoils with topsoil, and revegetation. Differences in legal requirements for rehabilitation among just the four States involved here illustrate the need for improved coordination of the legal aspects of surface-mine rehabilitation.

INFORMATION AND RESEARCH NEEDS

Throughout this report, the need for more research and better information has been implied, evident, or stated. The most important of these informational and research needs are listed below:

1.--Analyze and evaluate chemical and physical characteristics of surface-mine overburden materials before mining in relation to their suitability for revegetation purposes;

2.--Test and evaluate various spoil segregations and configurations for enhancement of rehabilitation success;

3.--Develop methods and techniques for creating favorable microbiological activity in previously sterile surface-mine spoils;

4.--Test and evaluate the comparative effects of different organic soil amendments in the revegetation of surface-mine spoils;

5.--Test and evaluate comparative effects of selected inorganic fertilizers in the revegetation of surface-mine spoils;

6.--Evaluate the physical and chemical quality of surface and subsurface runoff water from mine spoils under different rehabilitation treatments;

7.--Develop mechanical-chemical-vegetative techniques for rehabilitating steep, abandoned surface-mine spoils;

8.--Evaluate the effectiveness of semiarid farming techniques known to be effective on various kinds of mine spoils;

9.--Determine limits of establishment techniques identified in 8 (above);

10.--Develop mechanical criteria for construction of mine dumps or massive spoils to prevent mass slumping and to reduce surface erosion;

11.--Determine the physiological tolerances of selected plant ecotypes to various soil-water potential stresses and atmospheric evaporative-demand stresses on surface-mine spoil sites;

12.--Determine physiological tolerances of selected plant ecotypes to saline-alkaline stresses on various kinds of surface-mine spoils;

13.--Test and evaluate hormone-stimulated rooting characteristics of native shrubs on abandoned, oversteep mine spoils;

14.--Apply tissue-culturing techniques to develop increased tolerances of selected plant ecotypes to saline-alkaline stresses on surface-mine spoils;

15.--Determine posttreatment management practices requisite to successful permanent revegetation.

ORGANIZATIONS PROMINENTLY ACTIVE IN NORTHERN GREAT PLAINS REHABILITATION WORK

The railroad companies strip-mined coal and rehabilitated some areas in North Dakota and Montana nearly a half century ago. However, most surface mining activity in the Northern Great Plains coal province has developed within the past 7 or 8 years, and nearly all rehabilitation efforts within the last 5 years. The most prominently active organizations involved in surface-mine rehabilitation work in the Northern Great Plains are industry, Federal agencies, and State institutions. The mining industry has provided most of the efforts so far. These efforts, however, have not always been successful, partially because of a lack of adequate technical direction. The Federal agencies most active in this regard have been the Agricultural Research Service, especially its laboratory at Mandan, North Dakota; the Forest Service's Intermountain and Rocky Mountain Forest and Range Experiment Stations; the Soil Conservation Service; and the Bureau of Land Management. Probably the most active State institutions have been the Agricultural Experiment Station at Montana State University and the University of Wyoming. Although the Montana Highway Department has not been working directly on rehabilitation of surface-mined lands, it has been active in rehabilitation work on highway cuts and fills. In some instances, this work has direct application to surface-mine rehabilitation problems.

CONCLUSIONS

This survey and analysis of rehabilitation experience and potentials of the major coal and bentonite surface mines in the Northern Great Plains indicate several rather common problems. Perhaps the most common is leaving steep spoil slopes on unstable soil associations. Rilling and gullying start quickly, particularly where spoils have high sodium contents. Such erosion washes seed and fertilizer from areas that need revegetation. It also deprives soil of moisture needed if plant cover is to become established and persist. Preferably, grading slopes to permit rehabilitation work should be done cross slope where possible. Overburden conditions that are adverse to plant growth are often overlooked, although they are probably recognized in many cases. The existence of spoils that support no vegetative cover after years of exposure bears out this contention. Such materials should be recognized and buried.

Solutions to many conditions that have been called problems can be achieved by common sense, together with interest in and knowledge about determinants of plant growth. Nevertheless, variability occurs in sites, even within a single rehabilitation-response unit, despite gross overall similarities that may exist in climate, soil, and vegetation. This variability in site microenvironment contains some of the constraints that negate hard and fast rules about rehabilitation potentials. Good rehabilitation will continue to require spot-by-spot application of sound principles of plant-soil-water relations.

The author believes that almost all surface-mined sites in the Northern Great Plains can be successfully rehabilitated. Sites having the highest rehabilitation potentials occur in response units characterized by productive and stable soils, suitable and available plant species, and adequate amounts of precipitation. In general, these high-potential sites are in west-central North Dakota. Surface mineable sites that have intermediate rehabilitation potentials are predominant in southeastern Montana and extreme western North Dakota. Sites having the poorest potentials for rehabilitation occur in northeastern Wyoming and northeastern Montana, where rehabilitation-response units are characterized by poorly productive soils, native species that grow slowly and are difficult to obtain for rehabilitation purposes, and low amounts of precipitation.

Fortunately, those portions of the Northern Great Plains that present the most difficult rehabilitation problems are also the smallest areas that will be disturbed for a given amount of extracted coal. Conversely, the easiest rehabilitation problems exist in those portions of the Northern Great Plains where the largest areas will be disturbed per unit of extracted coal.

Comparisons of the rehabilitation-potential rankings indicate lack of uniformity in the relative ease of the rehabilitation job along with a shift from one coal-development forecast to another and from one time frame to another. Even with differences in areas to be mined in each forecast and time frame accounted for, substantial increases and decreases in the average rehabilitation-potential rankings (table 13) exist; the difficulty of the rehabilitation job will vary substantially between development forecasts and time frames. The author concludes that restructuring of mining developments between time frames within each development forecast could be accomplished by reselecting for mining the combination of rehabilitation-response units that collectively are of almost the same rehabilitation-potential ratings from time frame to time frame. Uniformity of and, hence, standardization of rehabilitation activities and programs in the Northern Great Plains coalfields would be greatly improved.

Neither the Federal Government nor the States have totally adequate laws governing surface-mine rehabilitation in the Northern Great Plains. There is no Federal law, and State laws do not have uniformly adequate provisions to assure application of known technology for rehabilitation of surface-mined lands. Better laws and effective enforcement will be required before even the best rehabilitation technology can be applied effectively to the land.

The author believes that almost all the surface-mined lands of the Northern Great Plains can be rehabilitated successfully. However, a large amount of basic information needs to be collected, and numerous research problems require solutions before such rehabilitation can proceed expeditiously, effectively, and economically.

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OPTIMUM REFUELING FOR HELICOPTER LOGGING: A MODEL

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USDA Forest Service General Technical Report INT-15, 1974
INTERMOUNTAIN FOREST & RANGE
EXPERIMENT STATION
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CONTENTS

Page

INTRODUCTION 1

PROBLEM DEFINITION 2

MODEL CONSTRUCTION 2

  Definitions of Terms 2

  Development of Equation 3

OPTIMIZATION 5

COMPUTER PROGRAM 7

EXAMPLES 9

SUMMARY 18

LITERATURE CITED 18

ABSTRACT

Effectiveness of a helicopter logging system, as measured by pounds of logs yarded or profit per day, is influenced by the amount of fuel carried by the aircraft. A cost model and computer program (FORTRAN IV) are presented that determine the optimum amount of fuel to carry for parameters of the operating system. The model can also be employed to assess effects of changes in parameters on the productivity of the system. The model can be used to establish a benchmark by which actual production can be predicted and monitored.

KEYWORDS: helicopter logging, optimization, refueling.

INTRODUCTION

Increased awareness of the environmental impact of logging has stimulated interest in yarding by means of helicopters. In addition, the great demand for wood products has made helicopter logging an attractive technique for harvesting timber heretofore inaccessible.

In recent years, the number of timber sales devoted exclusively to helicopter yarding has increased so dramatically that helicopter yarding is no longer in the experimental stages--its practicality has been established. Although approximately 20 helicopters are in use in logging operations today, helicopter yarding remains an expensive proposition. Stevens (1972, 1973) and Binkley (1972) have reported on various cost, production, and equipment capability aspects of helicopter logging.

The Intermountain Forest and Range Experiment Station at Bozeman, Montana, has been engaged in such an effort to improve the cost effectiveness of helicopter logging as part of a comprehensive study of advanced logging systems. This paper presents an optimum refueling model for helicopter logging. Given parameters within which the helicopter will operate, the model determines the optimum amount of fuel that the aircraft should carry and the resulting operating characteristics of the system. Potential improvements in production depend upon parameters of the system, but may generally be expected to vary about 10 percent within current operating ranges.

PROBLEM DEFINITION

The rationale behind the model is that every pound of fuel carried displaces a pound of payload. The more fuel the aircraft carries the longer it can operate before refueling, but also the smaller the average payload per turn. Thus a cost model that maximizes profit (or equivalently pounds yarded) over a given period of time is defined. The amount of fuel carried by the ship is treated as a variable. This is expressed as:

Z = value of timber yarded - costs incurred
= value of timber yarded - (total average cycle cost + cost to refuel + cost to travel to and from refueling + cost while system down).

MODEL CONSTRUCTION

Definitions of Terms

Terms used in the model are:

A = average fuel consumption rate (gal/min)
ADLR = average distance from landing to refueling point (ft)
ADLW = average distance from landing to woods (ft)
ADRW = average distance from refueling point to woods (ft)
AHT = average hooking time (min)
AVP = average payload per turn (lb)
C = amount of fuel carried (gal)
DTC = downtime cost ($/min)
F = fuel capacity of helicopter (gal)
FLF = flight load factor (average fraction of maximum load carried)
FDT = fraction of workday system down
OC = system operating cost while yarding ($/min)
P = payload of helicopter at full fuel (lb)
PUHT = average positioning and unhooking time (min)
RFC = refueling cost ($/min)
RFLT = reserve flight time (min)
SI = speed toward landing (ft/min)
SO = speed out to woods (ft/min)
TRF = time to refuel (min)
V = value of timber yarded ($/lb)
W = weight of fuel (lb/gal)
XL = length of workday (min)

Development of Equation

Each component of the cost equation is now defined using the terms given above.

A. Value of timber yarded

value of timber yarded per workday = (number of loads yarded per workday) × (average payload per turn) × (value of timber yarded).

(1) number of loads yarded per workday = N1 + NRF

The first term (N1) accounts for round trips from the woods to the landing and back; the second term (NRF) allows for the last trip from the woods to the landing before returning to refuel.

$$\mathrm{N1} = \frac{(\mathrm{XL} - \mathrm{XL} \cdot \mathrm{FDT}) - \mathrm{NRF}\,[\mathrm{TRF} + (\frac{\mathrm{ADLR+ADRW}}{\mathrm{SO}}) + (\frac{\mathrm{ADLW}}{\mathrm{SI}} + \mathrm{AHT} + \mathrm{PUHT})]}{[(\frac{\mathrm{SI} + \mathrm{SO}}{\mathrm{SI} \cdot \mathrm{SO}})\ \mathrm{ADLW} + \mathrm{AHT} + \mathrm{PUHT}]}$$

$$\mathrm{NRF} = \frac{(\mathrm{XL} - \mathrm{XL} \cdot \mathrm{FDT}) \cdot \mathrm{A}}{\mathrm{C} + \mathrm{TRF} \cdot \mathrm{A}}$$

(2) average payload per turn

The model is constructed to consider two alternative evaluations relative to payload:

(a) Theoretical average payload (AVP_t)

Conceptually, on each successive turn, the helicopter will be able to yard a greater payload since it is carrying less fuel. If loads were constructed to take advantage of this situation (it is approached when yarding material such as cement on construction projects), the average payload yarded would be:

$$\begin{aligned}\mathrm{AVP}_t = \mathrm{FLF} \cdot \{&[\mathrm{P} + (\mathrm{F} - \mathrm{C})\ \mathrm{W} - (\frac{\mathrm{RFLT}}{\mathrm{A}})\ \mathrm{W}] \\ &+ [\mathrm{A} \cdot \mathrm{W}\ (\mathrm{ADRW} \cdot \mathrm{SO}^{-1} + \mathrm{AHT}) \\ &+ .5(\mathrm{N}-1) \cdot \mathrm{A} \cdot \mathrm{W}\ (\mathrm{ADLW}\ (\frac{\mathrm{SI} + \mathrm{SO}}{\mathrm{SI} \cdot \mathrm{SO}}) \\ &+ \mathrm{AHT} + \mathrm{PUHT})]\}\end{aligned}$$

where N is the number of loads yarded between refuelings.

$$\mathrm{N} = \frac{[\mathrm{C} - (\frac{\mathrm{ADLR+ADRW}}{\mathrm{SO}})\mathrm{A} - (\frac{\mathrm{ADLW}}{\mathrm{SI}} + \mathrm{AHT} + \mathrm{PUHT})\mathrm{A}] + [\mathrm{ADLW}\ (\frac{\mathrm{SI+SO}}{\mathrm{SI \cdot SO}}) + \mathrm{AHT} + \mathrm{PUHT}]\mathrm{A}}{[\mathrm{ADLW}\ (\frac{\mathrm{SI+SO}}{\mathrm{SI \cdot SO}}) + \mathrm{AHT} + \mathrm{PUHT}]\mathrm{A}}$$

The second term in [ ] in the expression for AVP_t relates to conceptually being able to add a pound of timber for each pound of fuel consumed. It should be noted AVP_t is maximized when the flight load factor, FLF, is 1 and the reserve flight time, RFLT, is 0.

(b) actual average payload (AVP_a)

The expression for the actual average payload can be obtained by omitting the second term in [ ] in the expression for AVP_t.

$$AVP_a = FLF\ [P + (F - C)\ W - (\frac{RFLT}{A})\ W]$$

B. Total average cycle cost per workday (TACC)

$$TACC = N1\ [(\frac{SI + SO}{SI \cdot SO})\ ADLW + AHT + PUHT]\ OC$$

$$+ NRF\ (\frac{ADLW}{SI} + AHT + PUHT)\ OC$$

C. Cost to refuel per workday (CRF)

$$CRF = TRF \cdot RFC \cdot NRF$$

D. Cost to travel to and from refueling per workday (CTTR)

$$CTTR = NRF\ (\frac{ADLR + ADRW}{SO})\ OC$$

E. Cost while system down per workday (CSD)

$$CSD = FDT \cdot XL \cdot DTC$$

OPTIMIZATION

To find that value of C (the amount of fuel carried) that maximizes

$$Z = (N1 + NRF)\ AVP \cdot V - [TACC + CRF + CTTR + CSD],$$

we must differentiate with respect to C, set it equal to 0, and then solve for C. Differentiating the equation with respect to C and setting it equal to 0 results in an expression of the form

$$\alpha C^2 + \beta C + \gamma = 0$$

which is recognized as a quadratic equation with the solution

$$C = \frac{-\beta \pm (\beta^2 - 4 \cdot \alpha \cdot \gamma)^{\frac{1}{2}}}{2 \cdot \alpha}$$

α, β, and γ are constants involving the parameters of the system and are given below.

$$\alpha = \frac{W\ (.5A - 1)\ (XL - XL \cdot FDT)\ SI \cdot SO \cdot V}{(SI + SO)\ ADLW + AHT \cdot SI \cdot SO + PUHT \cdot SI \cdot SO}$$

$$\beta = \frac{2W\ (.5A - 1)\ (XL - XL \cdot FDT)\ SI \cdot SO \cdot V \cdot A \cdot TRF}{(SI + SO)\ ADLW + AHT \cdot SI \cdot SO + PUHT \cdot SI \cdot SO}$$

$$\begin{aligned}\gamma = {} & (A \cdot TRF)\ [XK5 \cdot XK3 \cdot V - XK7 \cdot XK4 \cdot V \\ & + (XL - XL \cdot FDT)\ A \cdot XK4 \cdot V - XK5 \cdot XK9] \\ & - [XK7 \cdot XK9 + (XL - XL \cdot FDT)\ A \cdot XK3 \cdot V \\ & - XK7 \cdot XK3 \cdot V - XK10]\end{aligned}$$

Computational variables used to express γ above are defined in table 1.

Table 1.--*Definitions of computational variables.*

$$XK5 = \frac{(XL - XL \cdot FDT)\ SI \cdot SO}{[(SI + SO)\ ADLW + AHT \cdot SI \cdot SO + PUHT \cdot SI \cdot SO]}$$

$$XK7 = \frac{[(XL - XL \cdot FDT)A]\ SI(ADLR + ADRW) + [(XL - XL \cdot FDT)A]\ [ADLW \cdot SO + AHT \cdot SI \cdot SO + PUHT \cdot SI \cdot SO]}{[(SI + SO)\ ADLW + AHT \cdot SI \cdot SO + PUHT \cdot SI \cdot SO]}$$

$$XK9 = [(\frac{SI + SO}{SI \cdot SO})\ ADLW + AHT + PUHT]\ OC$$

$$XK10 = (XL - XL \cdot FDT)\ A[(\frac{ADLW}{SI} + AHT + PUHT)\ OC + TRF \cdot RFC + (\frac{ADLR + ADRW}{SO})\ OC]$$

XK3 and XK4 are defined below in two cases, $XK3_a$, $XK4_a$ and $XK3_t$, $XK4_t$, depending upon whether AVP_a or AVP_t is being considered, respectively.

$$XK3_a = FLF\ [P + (F - \frac{RFLT}{A})\ W]$$

$$XK4_a = -\ FLF \cdot W$$

$$XK3_t = FLF\ \{[P + (F - \frac{RFLT}{A})\ W] + [\frac{-XK1 \cdot XK2}{XK1P} - XK2 + A \cdot W\ (ADRW \cdot SO^{-1} + AHT)]\}$$

$$XK4_t = \frac{XK2}{XK1P} - W$$

where

$$XK1 = A\ \{(\frac{ADLR + ADRW}{SO}) + (\frac{ADLW}{SI} + AHT + PUHT) - [ADLW\ (\frac{SI + SO}{SI \cdot SO}) + AHT + PUHT]\}$$

$$XK2 = .5A \cdot W\ [ADLW\ (\frac{SI + SO}{SI \cdot SO}) + AHT + PUHT]$$

$$XK1P = A\ [ADLW\ (\frac{SI + SO}{SI \cdot SO}) + AHT + PUHT]$$

COMPUTER PROGRAM

The computer program that calculates the optimum refueling amount together with the resulting system operating characteristics is available on request as a listing from the Forestry Sciences Laboratory, Bozeman, Montana 59715 (Attn: David F. Gibson). The program is written in FORTRAN IV. Input and output are designed for use of either a teletype terminal or a line printer. Examples illustrating alternative evaluations and use of the program are given in the next section.

Input to the program is as follows. On the first data card, or line on a terminal, eight variables are read with a format of F10.4 each. These variables are, in order, as follows.

SI - Helicopter speed toward the landing expressed in feet per minute. This represents the average speed of the aircraft when yarding.
SO - Helicopter speed out from landing expressed in feet per minute. This represents the average speed of the helicopter when it is not yarding, such as when returning to the woods and traveling to the refueling point.
ADLR - Average distance from the landing to the refueling point expressed in feet.
ADRW - Average distance from the refueling point to the woods expressed in feet.
ADLW - Average distance from the landing to the woods expressed in feet. This represents the average yarding distance.
A - Average fuel consumption rate of the aircraft expressed in gallons per minute.
W - Weight of fuel used by the aircraft expressed in pounds per gallon.
XL - Length of workday expressed in minutes.

The second data card of input, or line on a terminal, contains seven fields, the first six of which have a format of F10.4 and the last one having a format of I1.

RFC - Refueling cost expressed in dollars per minute. This is the cost of operating the entire helicopter logging system when the aircraft is being refueled.
P - Payload of the helicopter expressed in pounds when it is carrying a full load of fuel.
F - Fuel capacity of the helicopter expressed in gallons.
V - Value of the timber yarded expressed in dollars per pound.
AHT - Average hooking time expressed in minutes. This time also includes the time required to position the helicopter over the load prior to hooking.
FDT - Fraction of downtime expressed as a decimal. It represents the portion of the workday that the helicopter will be down for reasons other than refueling.

IGR - A control variable for the program. Enter a 0 if no graphical output is desired. Enter a 1 if a graph of weight yarded per workday versus refueling amount is desired. Enter a 2 if a graph of profit per workday versus refueling amount is desired. Enter a 3 if graphs of both weight and profit per workday versus refueling amount are desired. Flight time between refuelings is also given on the graphs.

Information entered on the third data card also contains seven fields, the first six of which have a format of F10.4 and the last has a format of I1.

OC - Operating cost of the system expressed in dollars per minute. This is the cost of the entire helicopter logging system while timber is being yarded by the aircraft.

TRF - Average time to refuel the aircraft expressed in minutes. This does not include the time required to travel to the refueling point or the time required to return to the woods.

PUHT - Average positioning and unhooking time expressed in minutes. This includes the time required to lift the hooked timber clear of standing trees, position over the landing, and release the load.

RFLT - Reserve flight time expressed in minutes. This represents the amount of flight time that is desired to be maintained in reserve as a safety measure.

FLF - Flight load factor expressed as a decimal. This represents the anticipated fraction of total lifting capacity of the aircraft that will be realized by the average load. For example, if it is anticipated that 70 percent of the aircraft's lifting capacity will be realized, on the average, for loads yarded, then an entry of 0.70 is made.

DTC - Downtime cost as expressed in dollars per minute. This is the cost of the entire helicopter logging system when the aircraft is down for reasons other than refueling.

KEY - This is another control variable for the program. If calculations are to be made considering AVP_a (explained in previous section), then a 0 or no entry is made. However, if calculations are to be made considering AVP_t (explained in previous section), a 1 is entered.

EXAMPLES

Five examples are presented to illustrate the use of the model. These are contrived examples. Their data (table 2) were not obtained from actual operations.

Table 2.--*Computer inputs for examples of helicopter logging*

Input variable	Example				
	I	II	III	IV	V
SI	3000.	3000.	3000.	3000.	3000.
SO	4000.	4000.	4000.	4000.	4000.
ADLR	2000.	2000.	2000.	2000.	0
ADRW	4800.	4800.	4800.	4800.	4000.
ADLW	4000.	4000.	4000.	4000.	4000.
A	3.5	3.5	3.5	3.5	3.5
W	6.5	6.5	6.5	6.5	6.5
XL	480.	480.	480.	480.	480.
RFC	8.	8.	8.	8.	8.
P	8000.	8000.	8000.	8000.	8000.
F	1000.	1000.	1000.	1000.	1000.
V	.015	.015	.015	.015	.015
AHT	2.0	2.0	2.0	2.0	2.0
FDT	.10	.00	.00	.00	.10
IGR	0	0	0	0	3.
OC	14.	14.	14.	14.	14.
TRF	8.	8.	8.	8.	8.
PUHT	.25	.25	.25	.25	.25
RFLT	10.	10.	10.	10.	10.
FLF	.70	.70	1.0	1.0	.70
DTC	8.	8.	8.	8.	8.
KEY	0	0	0	1.	0

Figures 1, 2, 3, and 4 show the computer output for examples I, II, III, and IV, respectively. Because the input variable IGR was set equal to 0 in these four examples, no graphical output resulted. Integers representing system characteristics have been rounded down. The productivity of the system increases successively from examples I to IV. The system represented in example II is more productive than the system in example I because the fraction of downtime (as input via variable FDT) decreases from 0.10 to 0.00 (all other inputs remained the same). Example III shows an increase in productivity over example II because the flight load factor (FLF) is increased from 0.70 to 1.0 while all other inputs remained unchanged. The system represented in example IV is more productive than that in example III, because AVP_t is considered instead of AVP_a. This is accomplished by setting the input variable KEY equal to 1.

```
**************************************************************
*                                                            *
*              HELICOPTER LOGGING ANALYSIS                   *
*                                                            *
*               OPTIMUM REFUELING MODEL                      *
*                                                            *
**************************************************************


                  ****************************
                  *                          *
                  *    SYSTEM PARAMETERS     *
                  *                          *
**************************************************************
*                                                            *
*  SPEED IN =  3000.0 FT/MIN    SPEED OUT =  4000.0 FT/MIN   *
*                                                            *
*  AVERAGE YARDING DISTANCE =  4000.0 FT                     *
*                                                            *
*  DISTANCE FROM LANDING TO REFUELING POINT =  2000.0 FT     *
*                                                            *
*  AVERAGE DISTANCE FROM REFUELING POINT TO WOODS =  4800.0 FT *
*                                                            *
*  WORK DAY =  480.0 MIN    SYSTEM OPERATING COST =  14.0 $/MIN *
*                                                            *
*  FRACTION DOWNTIME =  .10    DOWNTIME COST =   8.0 $/MIN   *
*                                                            *
*  PAYLOAD (FULL FUEL) =  8000.0 LB                          *
*                                                            *
*  FLIGHT LOAD FACTOR =  .70    REFUELING COST =   8.0 $/MIN *
*                                                            *
*  MAX FUEL CAPACITY =  1000.0 GAL                           *
*                                                            *
*  FUEL CONSUMPTION RATE =  3.5 GAL/MIN                      *
*                                                            *
*  RESERVE FLIGHT TIME =  10.0 MIN    TIME TO REFUEL =  8.0 MIN *
*                                                            *
*  AVERAGE HOOKING TIME =  2.0 MIN    TIMBER VALUE =  .015 $/LB *
*                                                            *
*  POSITION & UNHOOKING TIME =  .25 MIN                      *
*                                                            *
**************************************************************


             ****************************************
             *                                      *
             *    SYSTEM OPERATING CHARACTERISTICS  *
             *                                      *
**************************************************************
*                                                            *
*  REFUELING AMOUNT =   211.60  GAL     TURNS PER DAY =   82 *
*                                                            *
*  TURNS BETWEEN REFUELING =   13                            *
*                                                            *
*  FLIGHT TIME BETWEEN REFUELING =   60.5  MIN               *
*                                                            *
*  NUMBER OF REFUELINGS PER DAY =   6                        *
*                                                            *
*  PERCENT YARDING TIME =  77.2                              *
*                                                            *
*  PERCENT REFUELING TIME =  12.8                            *
*                                                            *
*  PERCENT DOWNTIME =  10.0                                  *
*                                                            *
*  PROFIT PER DAY =  $   5193.18                             *
*                                                            *
*  WEIGHT OF TIMBER YARDED PER DAY =     754817.63  LB       *
*                                                            *
**************************************************************
```

Figure 1.--Example I computer output.

```
**************************************************************
*                                                            *
*              HELICOPTER LOGGING ANALYSIS                   *
*                                                            *
*               OPTIMUM REFUELING MODEL                      *
*                                                            *
**************************************************************


                  ****************************
                  *                          *
                  *    SYSTEM PARAMETERS     *
                  *                          *
**************************************************************
*                                                            *
*  SPEED IN =  3000.0 FT/MIN    SPEED OUT =  4000.0 FT/MIN   *
*                                                            *
*  AVERAGE YARDING DISTANCE =  4000.0 FT                     *
*                                                            *
*  DISTANCE FROM LANDING TO REFUELING POINT =  2000.0 FT     *
*                                                            *
*  AVERAGE DISTANCE FROM REFUELING POINT TO WOODS =  4800.0 FT *
*                                                            *
*  WORK DAY =  480.0 MIN    SYSTEM OPERATING COST =  14.0 $/MIN *
*                                                            *
*  FRACTION DOWNTIME =  .00    DOWNTIME COST =   8.0 $/MIN   *
*                                                            *
*  PAYLOAD (FULL FUEL) =  8000.0 LB                          *
*                                                            *
*  FLIGHT LOAD FACTOR =  .70    REFUELING COST =   8.0 $/MIN *
*                                                            *
*  MAX FUEL CAPACITY =  1000.0 GAL                           *
*                                                            *
*  FUEL CONSUMPTION RATE =  3.5 GAL/MIN                      *
*                                                            *
*  RESERVE FLIGHT TIME =  10.0 MIN    TIME TO REFUEL =  8.0 MIN *
*                                                            *
*  AVERAGE HOOKING TIME =  2.0 MIN    TIMBER VALUE =  .015 $/LB *
*                                                            *
*  POSITION & UNHOOKING TIME =  .25 MIN                      *
*                                                            *
**************************************************************


             ****************************************
             *                                      *
             *    SYSTEM OPERATING CHARACTERISTICS  *
             *                                      *
**************************************************************
*                                                            *
*  REFUELING AMOUNT =   211.60  GAL     TURNS PER DAY =   91 *
*                                                            *
*  TURNS BETWEEN REFUELING =   13                            *
*                                                            *
*  FLIGHT TIME BETWEEN REFUELING =   60.5  MIN               *
*                                                            *
*  NUMBER OF REFUELINGS PER DAY =   7                        *
*                                                            *
*  PERCENT YARDING TIME =  85.8                              *
*                                                            *
*  PERCENT REFUELING TIME =  14.2                            *
*                                                            *
*  PERCENT DOWNTIME =    .0                                  *
*                                                            *
*  PROFIT PER DAY =  $   6196.85                             *
*                                                            *
*  WEIGHT OF TIMBER YARDED PER DAY =     838686.69  LB       *
*                                                            *
**************************************************************
```

Figure 2.--Example II computer output.

```
*                                                                          *
*                     HELICOPTER LOGGING ANALYSIS                          *
*                                                                          *
*                      OPTIMUM REFUELING MODEL                             *
*                                                                          *
****************************************************************************


                      ****************************
                      *                          *
                      *    SYSTEM PARAMETERS     *
                      *                          *
****************************************************************************
*                                                                          *
*                                                                          *
*   SPEED IN =   3000.0 FT/MIN     SPEED OUT =   4000.0 FT/MIN             *
*                                                                          *
*   AVERAGE YARDING DISTANCE =   4000.0 FT                                 *
*                                                                          *
*   DISTANCE FROM LANDING TO REFUELING POINT =   2000.0 FT                 *
*                                                                          *
*   AVERAGE DISTANCE FROM REFUELING POINT TO WOODS =   4800.0 FT           *
*                                                                          *
*   WORK DAY =   480.0 MIN     SYSTEM OPERATING COST =   14.0 $/MIN        *
*                                                                          *
*   FRACTION DOWNTIME =   .00     DOWNTIME COST =    8.0 $/MIN             *
*                                                                          *
*   PAYLOAD (FULL FUEL) =   8000.0 LB                                      *
*                                                                          *
*   FLIGHT LOAD FACTOR = 1.00     REFUELING COST =    8.0 $/MIN            *
*                                                                          *
*   MAX FUEL CAPACITY =   1000.0 GAL                                       *
*                                                                          *
*   FUEL CONSUMPTION RATE =   3.5 GAL/MIN                                  *
*                                                                          *
*   RESERVE FLIGHT TIME =   10.0 MIN     TIME TO REFUEL =   8.0 MIN        *
*                                                                          *
*   AVERAGE HOOKING TIME =   2.0 MIN     TIMBER VALUE =   .015 $/LB        *
*                                                                          *
*   POSITION & UNHOOKING TIME =   .25 MIN                                  *
*                                                                          *
*                                                                          *
****************************************************************************


             *****************************************************
             *                                                   *
             *        SYSTEM OPERATING CHARACTERISTICS           *
             *                                                   *
****************************************************************************
*                                                                          *
*                                                                          *
*   REFUELING AMOUNT =    218.57   GAL      TURNS PER DAY =    91          *
*                                                                          *
*   TURNS BETWEEN REFUELING =     13                                       *
*                                                                          *
*   FLIGHT TIME BETWEEN REFUELING =    62.4  MIN                           *
*                                                                          *
*   NUMBER OF REFUELINGS PER DAY =    6                                    *
*                                                                          *
*   PERCENT YARDING TIME =   86.2                                          *
*                                                                          *
*   PERCENT REFUELING TIME =   13.8                                        *
*                                                                          *
*   PERCENT DOWNTIME =      .0                                             *
*                                                                          *
*   PROFIT PER DAY =   $   11590.49                                        *
*                                                                          *
*   WEIGHT OF TIMBER YARDED PER DAY =      1198894.00   LB                 *
*                                                                          *
*                                                                          *
****************************************************************************
```

Figure 3.--Example III computer output.

```
*                                                                          *
*                     HELICOPTER LOGGING ANALYSIS                          *
*                                                                          *
*                      OPTIMUM REFUELING MODEL                             *
*                                                                          *
****************************************************************************


                      ****************************
                      *                          *
                      *    SYSTEM PARAMETERS     *
                      *                          *
****************************************************************************
*                                                                          *
*                                                                          *
*   SPEED IN =   3000.0 FT/MIN     SPEED OUT =   4000.0 FT/MIN             *
*                                                                          *
*   AVERAGE YARDING DISTANCE =   4000.0 FT                                 *
*                                                                          *
*   DISTANCE FROM LANDING TO REFUELING POINT =   2000.0 FT                 *
*                                                                          *
*   AVERAGE DISTANCE FROM REFUELING POINT TO WOODS =   4800.0 FT           *
*                                                                          *
*   WORK DAY =   480.0 MIN     SYSTEM OPERATING COST =   14.0 $/MIN        *
*                                                                          *
*   FRACTION DOWNTIME =   .00     DOWNTIME COST =    8.0 $/MIN             *
*                                                                          *
*   PAYLOAD (FULL FUEL) =   8000.0 LB                                      *
*                                                                          *
*   FLIGHT LOAD FACTOR = 1.00     REFUELING COST =    8.0 $/MIN            *
*                                                                          *
*   MAX FUEL CAPACITY =   1000.0 GAL                                       *
*                                                                          *
*   FUEL CONSUMPTION RATE =   3.5 GAL/MIN                                  *
*                                                                          *
*   RESERVE FLIGHT TIME =   10.0 MIN     TIME TO REFUEL =   8.0 MIN        *
*                                                                          *
*   AVERAGE HOOKING TIME =   2.0 MIN     TIMBER VALUE =   .015 $/LB        *
*                                                                          *
*   POSITION & UNHOOKING TIME =   .25 MIN                                  *
*                                                                          *
*                                                                          *
****************************************************************************


             *****************************************************
             *                                                   *
             *        SYSTEM OPERATING CHARACTERISTICS           *
             *                                                   *
****************************************************************************
*                                                                          *
*                                                                          *
*   REFUELING AMOUNT =    319.01   GAL      TURNS PER DAY =    95          *
*                                                                          *
*   TURNS BETWEEN REFUELING =     19                                       *
*                                                                          *
*   FLIGHT TIME BETWEEN REFUELING =    91.1  MIN                           *
*                                                                          *
*   NUMBER OF REFUELINGS PER DAY =    4                                    *
*                                                                          *
*   PERCENT YARDING TIME =   90.2                                          *
*                                                                          *
*   PERCENT REFUELING TIME =    9.8                                        *
*                                                                          *
*   PERCENT DOWNTIME =      .0                                             *
*                                                                          *
*   PROFIT PER DAY =   $   12730.22                                        *
*                                                                          *
*   WEIGHT OF TIMBER YARDED PER DAY =      1281188.00   LB                 *
*                                                                          *
*                                                                          *
****************************************************************************
```

Figure 4.--Example IV computer output.

Table 3.--*Summary of computer output for examples of helicopter logging*

	Example				
	I	II	III	IV	V
Refueling amount (gal)	212	212	219	319	200
Turns per day	82	91	91	95	82
Turns between refuelings	13	13	13	19	12
Flight time between refuelings (min)	61	61	62	91	57
Number of refuelings per day	6	7	6	4	6
Percent yarding time	77	86	86	90	78
Percent refueling time	13	14	14	10	12
Percent downtime	10	0	0	0	10
Profit per day ($)	5,193	6,197	11,590	12,730	5,330
Weight of timber yarded per day (lb)	754,818	838,687	1,198,894	1,281,188	762,862

Graphs of C (refueling amount) versus weight yarded and profit per workday are given by figures 5 and 6, respectively, for examples I through IV. Each line on the graphs is designated by the appropriate example number. The increase in productivity mentioned previously can also be discerned on these graphs. It can be seen that the curves are fairly flat in the region near optimality, but it is more costly to "underfuel" than to "overfuel" the aircraft. Note that figures 5 and 6 were not obtained from the program, but resulted from running a similar program on a CALCOMP plotter. The program described is designed for output on a teletype or a line printer because these modes of output are commonly available.

Figure 7 illustrates the graphical output of the program for example V. This example has the same input as example I except for ADLR, ADRW, and IGR. To illustrate the effect of locating the refueling point at the landing, ADLR was set equal to 0 and ADRW was set equal to ADLW. Also, to obtain graphs of both weight yarded and profit per workday versus amount of refueling, the input variable IGR was set equal to 3. Table 3 summarizes the output of the five examples.

An illustration of the many alternative evaluations available to the user follows. Assume that the system being evaluated is characterized by the input data of example V and hence the results are as given in figure 7. Suppose, however, that the flight time between refueling cannot be 57 minutes as optimally prescribed, but must be 40 minutes. This latter time is located on the graphs, and the gallons to be refueled, the weight yarded, and the profit per workday are approximated at 140 gallons, 746,000 pounds, and $5,190, respectively.

If an evaluation is to be accomplished where the helicopter remains running during refueling, the following consideration should be made. Fuel burned during refueling is considered to be obtained from the reserve flight time and should be added to the prescribed amount C to obtain the total refueling amount. As shown by figure 8, the amount that should be refueled is c + d, that is, the prescribed amount plus the amount burned during refueling.

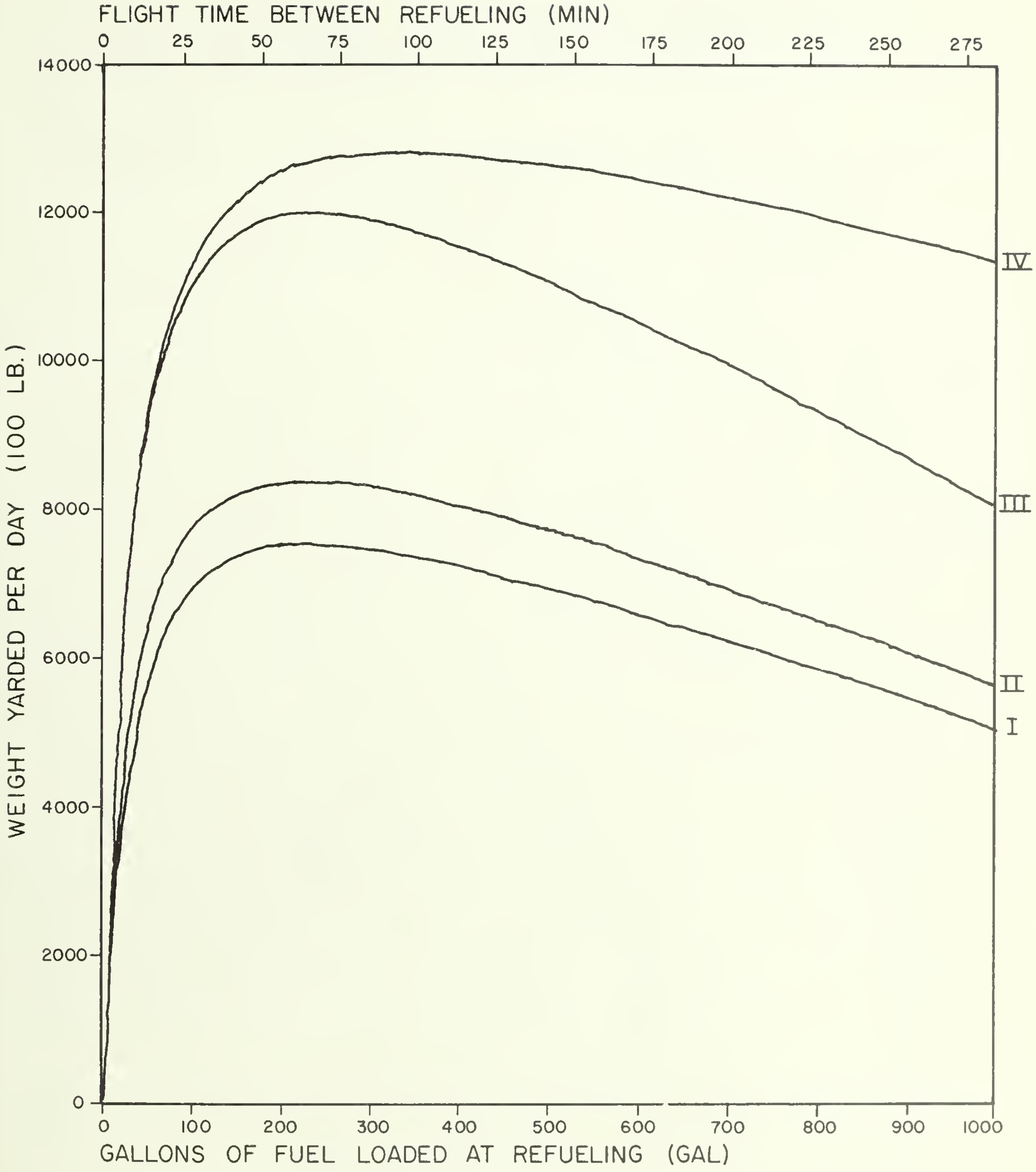


Figure 5.--Weight yarded per workday versus refueling amount for examples I, II, III, and IV.

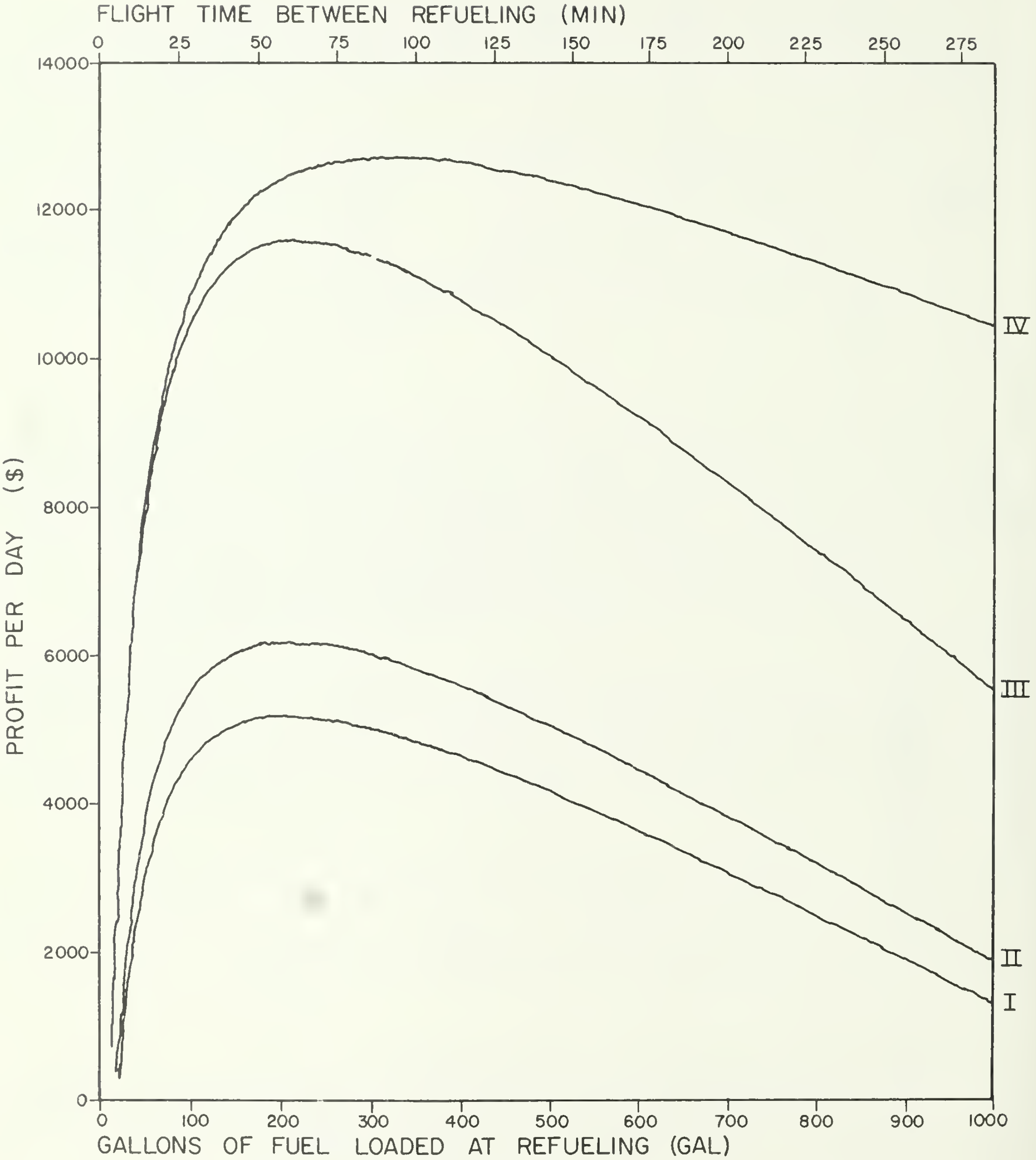


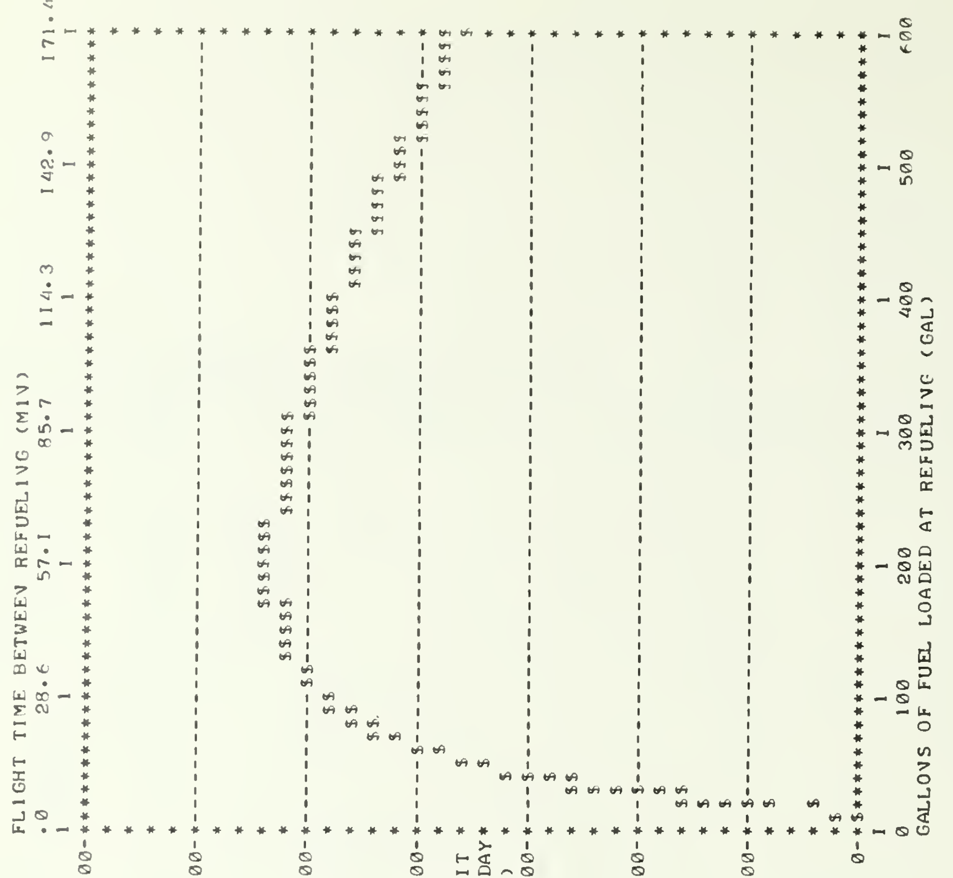
Figure 6.--Profit per workday versus refueling amount for examples I, II, III, and IV.

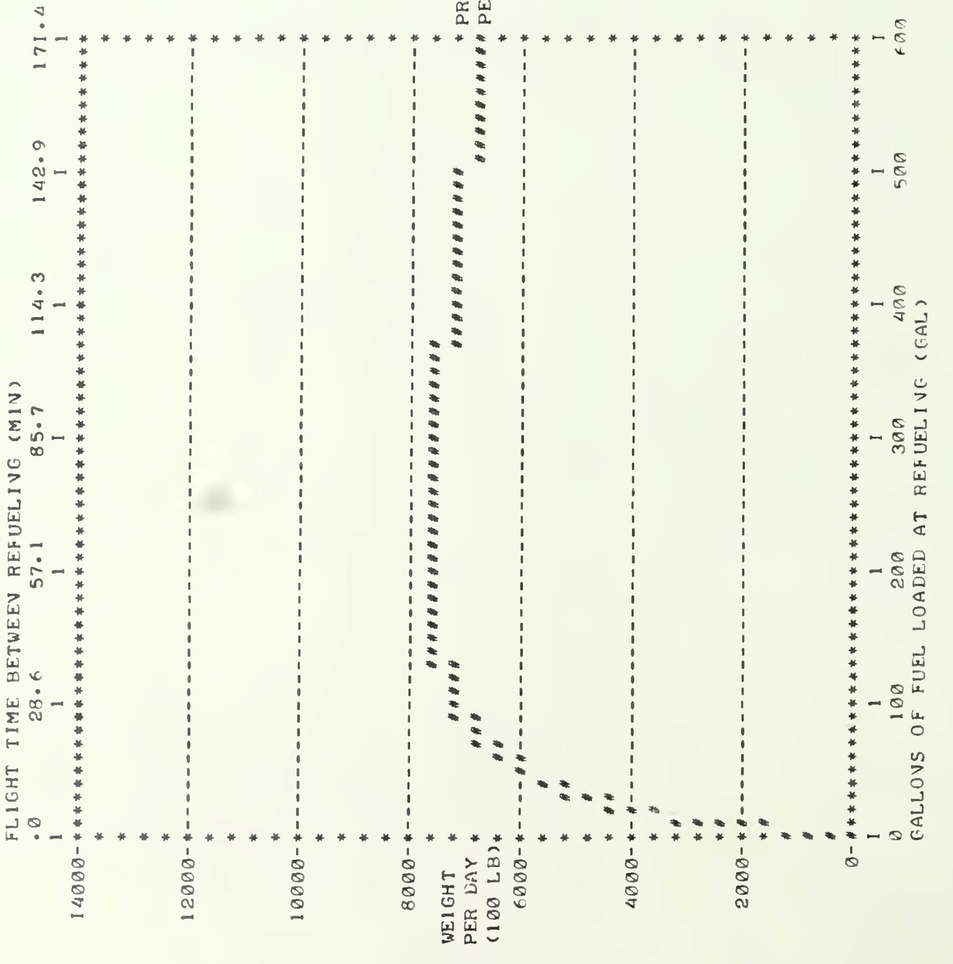
```
*****************************************************************
*                                                               *
*                 HELICOPTER LOGGING ANALYSIS                   *
*                                                               *
*                   OPTIMUM REFUELING MODEL                     *
*                                                               *
*****************************************************************
```

```
                  ***************************
                  *                         *
                  *    SYSTEM PARAMETERS    *
                  *                         *
*****************************************************************
*                                                               *
*                                                               *
*  SPEED IN =  3000.0 FT/MIN    SPEED OUT =  4000.0 FT/MIN      *
*                                                               *
*  AVERAGE YARDING DISTANCE =  4000.0 FT                        *
*                                                               *
*  DISTANCE FROM LANDING TO REFUELING POINT =       .0 FT       *
*                                                               *
*  AVERAGE DISTANCE FROM REFUELING POINT TO WOODS =  4000.0 FT  *
*                                                               *
*  WORK DAY =  480.0 MIN    SYSTEM OPERATING COST =  14.0 $/MIN *
*                                                               *
*  FRACTION DOWNTIME =  .10    DOWNTIME COST =    8.0 $/MIN     *
*                                                               *
*  PAYLOAD (FULL FUEL) =  8000.0 LB                             *
*                                                               *
*  FLIGHT LOAD FACTOR =  .70    REFUELING COST =    8.0 $/MIN   *
*                                                               *
*  MAX FUEL CAPACITY =  1000.0 GAL                              *
*                                                               *
*  FUEL CONSUMPTION RATE =  3.5 GAL/MIN                         *
*                                                               *
*  RESERVE FLIGHT TIME =  10.0 MIN     TIME TO REFUEL =  8.0 MIN *
*                                                               *
*  AVERAGE HOOKING TIME =  2.0 MIN     TIMBER VALUE =  .015 $/LB *
*                                                               *
*  POSITION & UNHOOKING TIME =  .25 MIN                         *
*                                                               *
*                                                               *
*****************************************************************
```

```
     *******************************************
     *                                         *
     *    SYSTEM OPERATING CHARACTERISTICS     *
     *                                         *
*****************************************************************
*                                                               *
*                                                               *
*  REFUELING AMOUNT =   199.78  GAL     TURNS PER DAY =   82    *
*                                                               *
*  TURNS BETWEEN REFUELING =   12                               *
*                                                               *
*  FLIGHT TIME BETWEEN REFUELING =   57.1  MIN                  *
*                                                               *
*  NUMBER OF REFUELINGS PER DAY =   6                           *
*                                                               *
*  PERCENT YARDING TIME =  77.6                                 *
*                                                               *
*  PERCENT REFUELING TIME =  12.4                               *
*                                                               *
*  PERCENT DOWNTIME =  10.0                                     *
*                                                               *
*  PROFIT PER DAY =  $   5329.56                                *
*                                                               *
*  WEIGHT OF TIMBER YARDED PER DAY =     762861.56  LB          *
*                                                               *
*                                                               *
*****************************************************************
```

(Con. next page)


FLIGHT TIME BETWEEN REFUELING (MIN)
.0
28.6
57.1
85.7
114.3
142.9
171.4
7000
6000
5000
4000
3000
2000
1000
0
PROFIT
PER DAY
($)
0
100
200
300
400
500
600
GALLONS OF FUEL LOADED AT REFUELING (GAL)


FLIGHT TIME BETWEEN REFUELING (MIN)
.0
28.6
57.1
85.7
114.3
142.9
171.4
14000
12000
10000
8000
6000
4000
2000
0
WEIGHT
PER DAY
(100 LB)
0
100
200
300
400
500
600
GALLONS OF FUEL LOADED AT REFUELING (GAL)

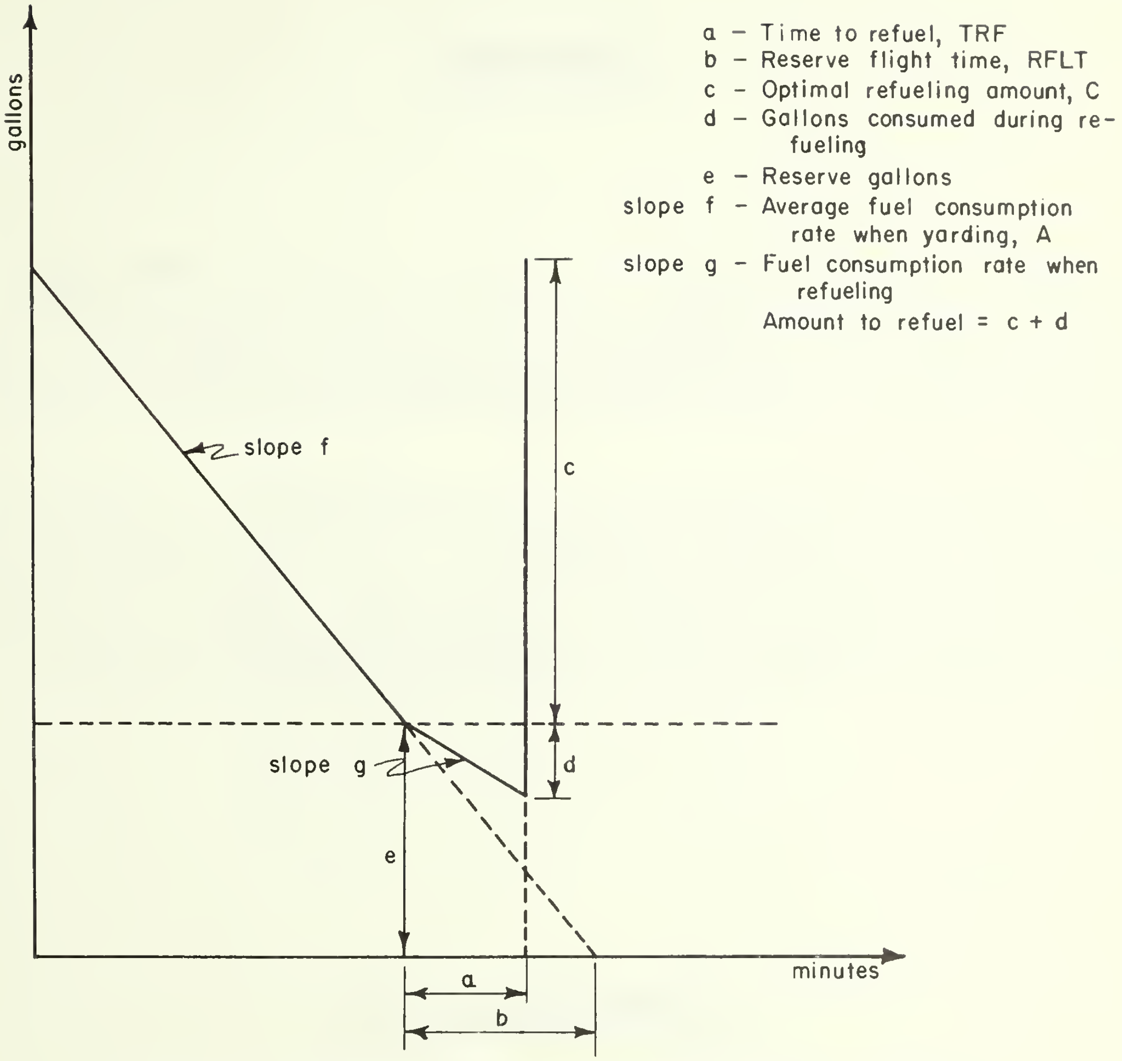
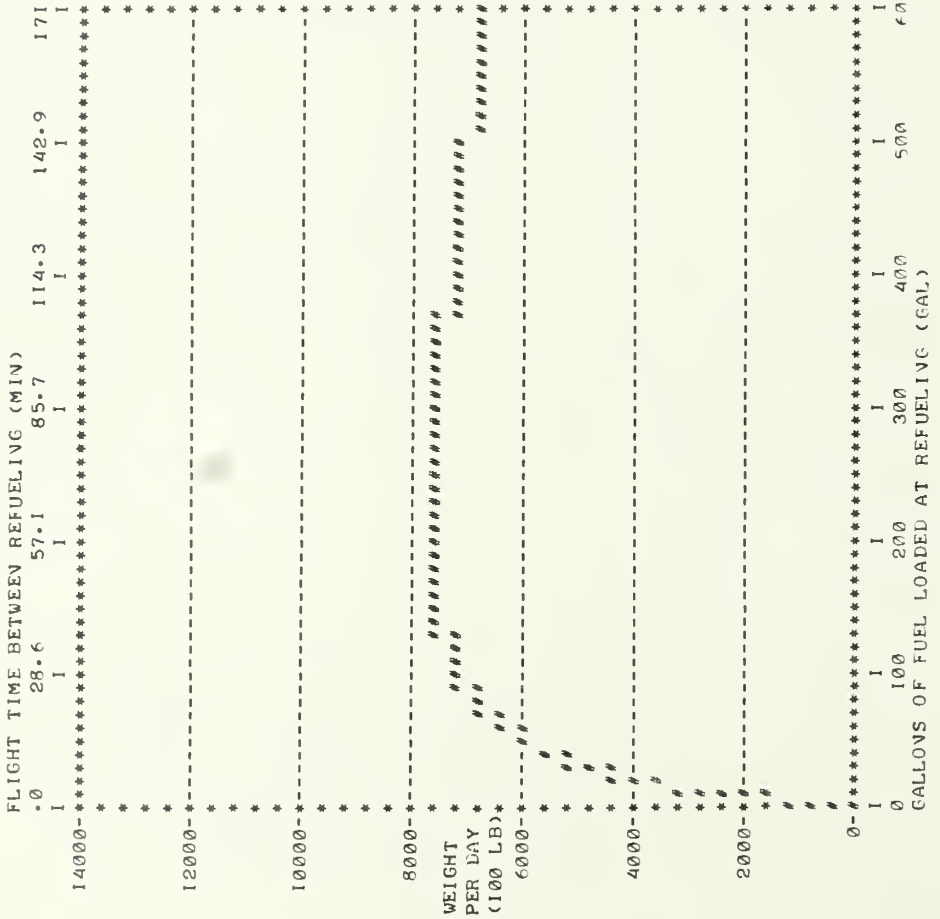
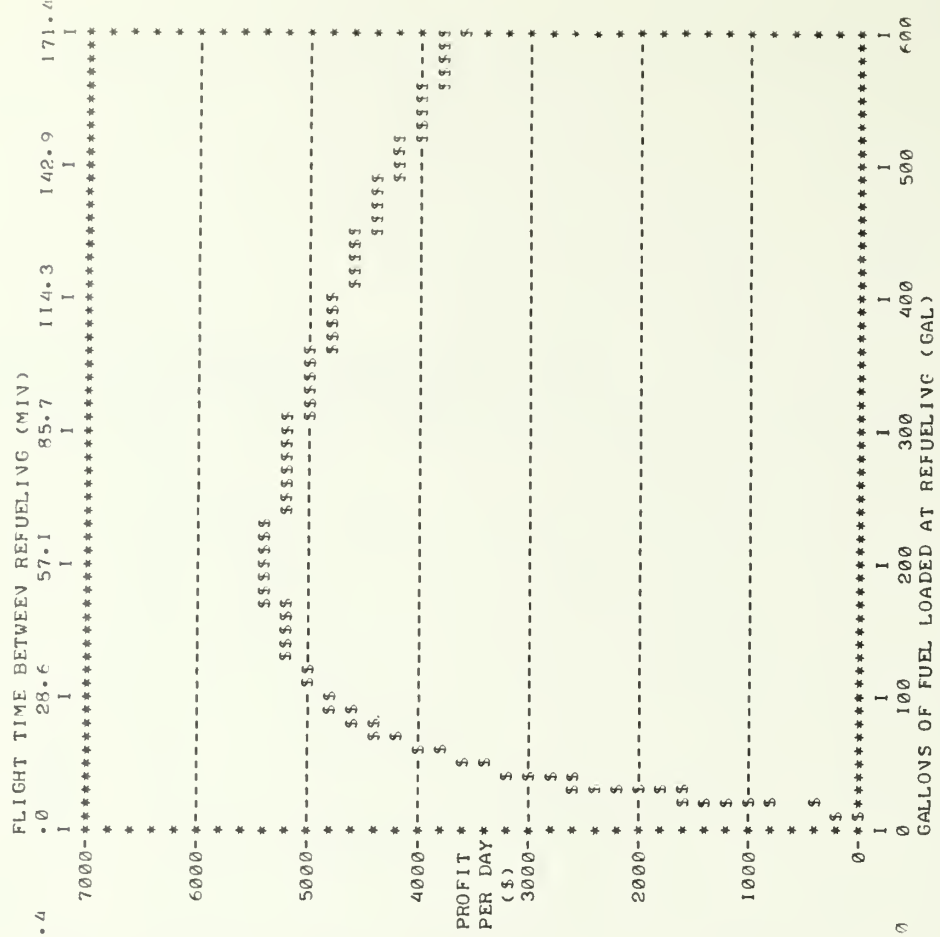

gallons
minutes
slope f
slope g
a
b
c
d
e
a – Time to refuel, TRF
b – Reserve flight time, RFLT
c – Optimal refueling amount, C
d – Gallons consumed during refueling
e – Reserve gallons
slope f – Average fuel consumption rate when yarding, A
slope g – Fuel consumption rate when refueling
Amount to refuel = c + d

Figure 8.--Calculation of fuel load when helicopter remains running while being refueled.


FLIGHT TIME BETWEEN REFUELING (MIN)
.0
28.6
57.1
85.7
114.3
142.9
171.4
14000
12000
10000
8000
WEIGHT PER DAY (100 LB)
6000
4000
2000
0
0
100
200
300
400
500
600
GALLONS OF FUEL LOADED AT REFUELING (GAL)


FLIGHT TIME BETWEEN REFUELING (MIN)
.0
28.6
57.1
85.7
114.3
142.9
7000
6000
5000
4000
PROFIT PER DAY ($)
3000
2000
1000
0
0
100
200
300
400
500
600
GALLONS OF FUEL LOADED AT REFUELING (GAL)

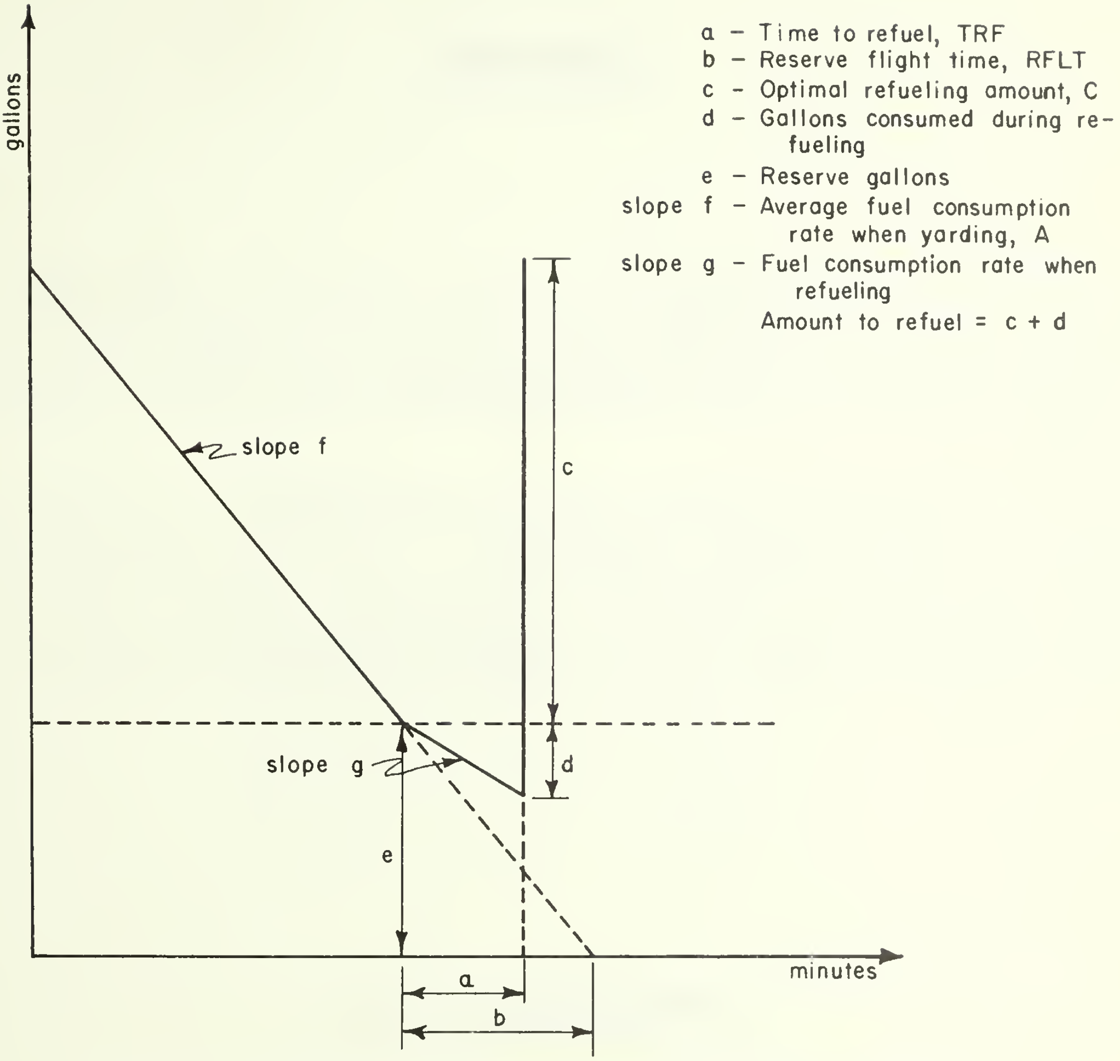

a – Time to refuel, TRF
b – Reserve flight time, RFLT
c – Optimal refueling amount, C
d – Gallons consumed during refueling
e – Reserve gallons
slope f – Average fuel consumption rate when yarding, A
slope g – Fuel consumption rate when refueling
Amount to refuel = c + d
gallons
slope f
c
slope g
d
e
a
b
minutes

Figure 8.--Calculation of fuel load when helicopter remains running while being refueled.

SUMMARY

Yarding by means of a helicopter has a number of advantages, notably minimal environmental impact and the capability to harvest otherwise inaccessible timber. A helicopter logging operation is fairly expensive; because of this, thorough planning and control efforts are more imperative than for conventional logging methods. The cost effectiveness of a helicopter logging operation is very sensitive to parameters of and decisions pertaining to the system. Every effort should be made to maximize efficiency.

The model presented in this paper prescribes within parameters of the system optimal refueling for a helicopter logging operation. The model has been programed in FORTRAN IV and is well documented. Several features have been incorporated in the program to permit the user to accomplish alternative evaluations. Effects of variables such as yarding distance, location of the landing, flight load factor, costs, and others can easily be assessed. The model can also be used to predict production under given circumstances and can be used as a benchmark for monitoring production.

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1973. Economic and safety aspects of helicopter logging: FALCON report. The Aerospace Corp., USDA For. Serv., PNW Grant 9, 37 p.

U.S. GOVERNMENT PRINTING OFFICE: 1974 — 677-087 / 2 REGION NO. 8

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HANDBOOK FOR INVENTORYING DOWNED WOODY MATERIAL

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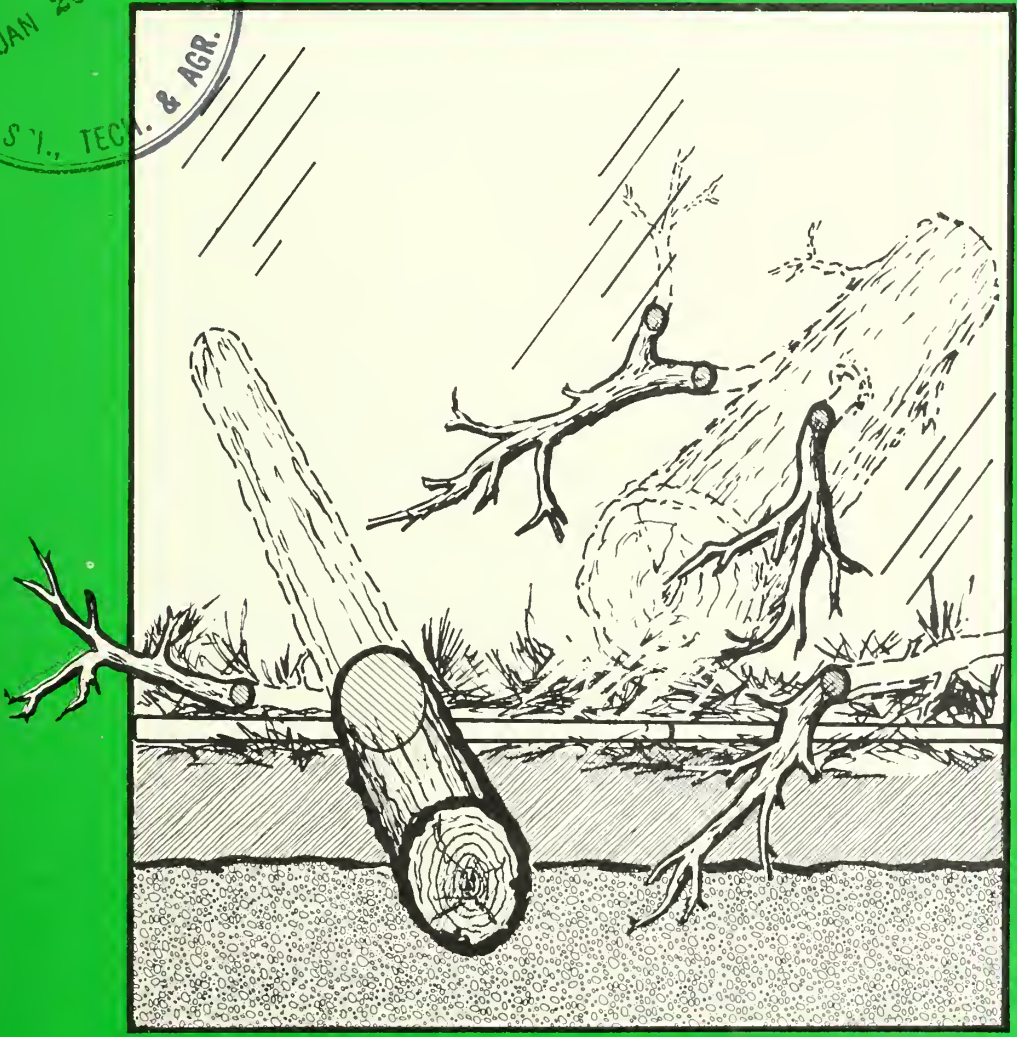

USDA Forest Service General Technical Report INT-16, 1974
INTERMOUNTAIN FOREST & RANGE
EXPERIMENT STATION
Ogden, Utah 84401

USDA Forest Service
General Technical Report INT-16
September 1974

HANDBOOK FOR INVENTORYING DOWNED WOODY MATERIAL

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INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION
Forest Service
U.S. Department of Agriculture
Ogden, Utah 84401
Roger R. Bay, Director

THE AUTHOR

JAMES K. BROWN received his bachelor's degree from the University of Minnesota in 1960, his master's from Yale University in 1961, and his Ph. D. from the University of Michigan in 1968, all in forestry. From 1961 to 1965 he did research on field measurement of fuel properties and fire-danger rating systems while with the Lake States Forest Experiment Station. In 1965 he transferred to the Northern Forest Fire Laboratory, Missoula, Montana, where he is responsible for research on the physical properties and inventory of fuel.

CONTENTS

Page

INTRODUCTION 1

NUMBER AND SIZE OF SAMPLING PLANES 3

FIELD PROCEDURES 4

  Locating Sample Points 4

  Sample Point Procedures 4

    Tally Rules 9
    Heavy Slash Options 11
    Utilization Options 12

  Field Equipment 12

CALCULATIONS 13

FURTHER APPLICATIONS 19

LITERATURE CITED 20

APPENDIX I 21

  Sampling Intensities 21

  Number and Size of Sampling Planes 21

  Sampling Precision for Depth Measurements 22

APPENDIX II 23

  Specific Gravities of Sound Material 23

APPENDIX III 24

  Calculating Needle Quantities 24

ABSTRACT

To facilitate debris management, procedures for inventorying downed woody material are presented. Instructions show how to estimate weights and volumes of downed woody material, fuel depth, and duff depth. Using the planar intersect technique, downed material is inventoried by 0- to 0.25-inch, 0.25- to 1-inch, and 1- to 3-inch diameter classes; and by 1-inch classes for sound and rotten pieces over 3 inches. The method is rapid and easy to use and can be applied to naturally fallen debris and to slash. The method involves counting downed woody pieces that intersect vertical sampling planes and measuring the diameters of pieces larger than 3 inches in diameter. The piece counts and diameters permit calculation of tons per acre.

OXFORD: 431

KEYWORDS: fire causes (forest), fuel inventory, forest fuels, debris, planar intersect method, sampling methods.

INTRODUCTION

This Handbook tells how to inventory weights, volumes, and depths of downed woody aterial. Downed woody material is the dead twigs, branches, stems, and boles of trees nd brush that have fallen and lie on or above the ground. This material is usually alled slash or logging debris if man creates it by cutting; it is called fuel, atural debris, or detritus if it accumulates without cutting.

Inventorying downed woody material can help land managers practice fuel manageent, plan for prescribed fire, and estimate utilization potential. For example, ndesirable fuel hazards can be identified and plans made for hazard reduction. Fire ehavior in wilderness areas can be predicted to aid in implementing let-burn fire olicies. The volume of downed fiber can be estimated to plan for sales, removal, nd utilization. Managers can communicate in exact terms about their debris problems.

The inventory can be done to provide all or any part of the following information:

1. Weights and volumes per acre of downed woody material for
    a. Diameter size classes of 0 to 0.25, 0.25 to 1, and 1 to 3 inches; and
    b. Diameters of 3 inches and larger for sound and rotten conditions.
2. Average diameter of debris larger than 3 inches.
3. Depth of fuel and forest floor duff.

This Handbook applies most accurately in the western United States because it ntains average particle diameters for western conifers; however, the procedures are propriate for forests everywhere. The inventory procedures are rapid and easy to use. For average amounts of downed debris, about 5 to 6 minutes per sample point are required for the measurements. More time is usually spent in traveling and locating sample points than in making the measurements. If only downed woody material is inventoried, a two-man crew can complete 20 to 40 plots a day, depending on how much debris is present.

The inventory of volumes and weights is based on the planar intersect technique (Brown 1971; Brown and Roussopoulos 1974), which has the same theoretical basis as the line intersect technique (Van Wagner 1968). The planar intersect technique involves counting intersections of woody pieces with vertical sampling planes that resemble guillotines dropped through the downed debris. Volume is estimated; then weight is calculated from volume by applying estimates of specific gravity of woody material. The planar intersect technique is nondestructive and avoids the time-consuming, costly, and often impractical task of collecting and weighing large quantities of forest debris.

Woody pieces less than 3 inches in diameter are tallied by size classes. Pieces 3 inches and larger are recorded by their diameters. Size classes of 0 to 0.25, 0.25 to 1, and 1 to 3 inches were chosen for tallying intersections because:

1. The class intervals provide the most resolution for fine fuels and are small enough to permit precise estimates of volume.

2. They correspond, in increasing size, to 1-, 10-, and 100-hour average moisture timelag classes for many woody materials (Fosberg 1970). [These are standard moisture timelags used in the National Fire-Danger Rating System (Deeming and others 1972).]

Inventory chosen areas as follows:

1. Decide on length of sampling planes and number of sample points.

2. Complete the fieldwork.

3. Calculate weight or volume, size, and depth of debris.

NUMBER AND SIZE OF SAMPLING PLANES

Choose sampling plane lengths from the following tabulation:

Downed material	*Diameter of debris*		
	0-1 in	*1-3 in*	*>3 in*
	Sampling plane (ft)		
Nonslash (naturally fallen material)	6	10-12	35-50
Discontinuous light slash	6	10-12	35-50
Continuous heavy slash	3	6	15-25

For any area where estimates are desired, 15 to 20 sample points should be located using the sampling plane lengths shown in the tabulation. This sampling intensity will often yield estimates having standard errors within 20 percent of the mean estimates. Areas larger than approximately 50 acres that contain a high diversity in amount and distribution of downed material should be sampled with more than 20 points. If material larger than 3 inches in diameter is scanty or unevenly distributed, the longer sampling planes in the tabulation should be used.

The amount and distribution of downed woody material vary greatly among and within stands. Thus, these sampling recommendations should be considered approximate because a greater or fewer number of plots may be required to furnish adequate precision for any given area. Sampling intensities are discussed further in Appendix I.

FIELD PROCEDURES

Locating Sample Points

Locate plots systematically; two methods are:

1. Locate plots at a fixed interval along transects that lace regularly across a sample area (uniform sampling grid). For example, on a sample area, mark off parallel transects that are 5 to 10 chains apart. Then along the transects locate plots at 2- to 5-chain intervals.

2. Locate plots at a fixed interval along a transect that runs diagonally through the sample area. To minimize bias, have the transect cross obvious changes in fuels. Before entering the sample area, determine a transect azimuth and distance between plots.

Sample Point Procedures

Step 1: *Mark the sampling point* with a chaining pin (No. 9 wire or similar item). Avoid disturbing material around the point. Accurate estimates require measurements of undisturbed material. If standing tree measurements (d.b.h. and height) are a part of the inventory, measure downed material first.

Step 2: *Determine direction of sampling plane* by tossing a die to indicate one of six 30° angles between 0° and 150° (fig. 1). The 0° heading is the transect direction. Turn a fixed direction, such as clockwise, to position the sampling plane. As an alternative for indicating direction of the sampling plane, use the position of the second hand on a watch at a given instant. To avoid bias in placement of the sampling plane, do not look at the fuel or ground while turning the interval.

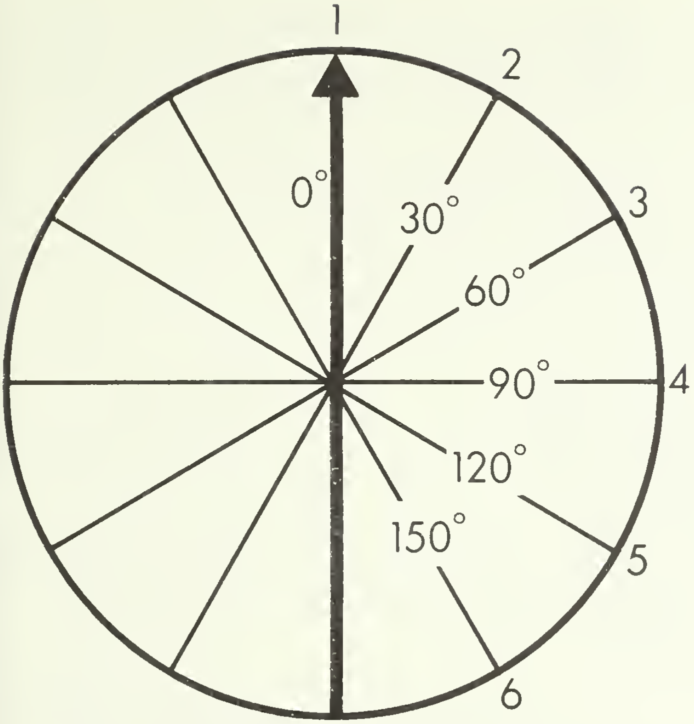


Figure 1.--Locating sampling plane by using die to pick one of six directions.

Step 3: *Denote position of the sampling plane* by running a tape or string out from the sampling point *parallel to the ground* in the direction determined in Step 2 (fig. 2). Extend the tape to the length of the longest sampling plane. A fiberglass rod or 1/2-inch aluminum tube placed along the string beginning at the sampling point facilitates counting pieces less than 1 inch in diameter. The rod should be 6 feet long, the length of sampling plane for small particles. The tape and rod fix the position of vertical sampling planes.

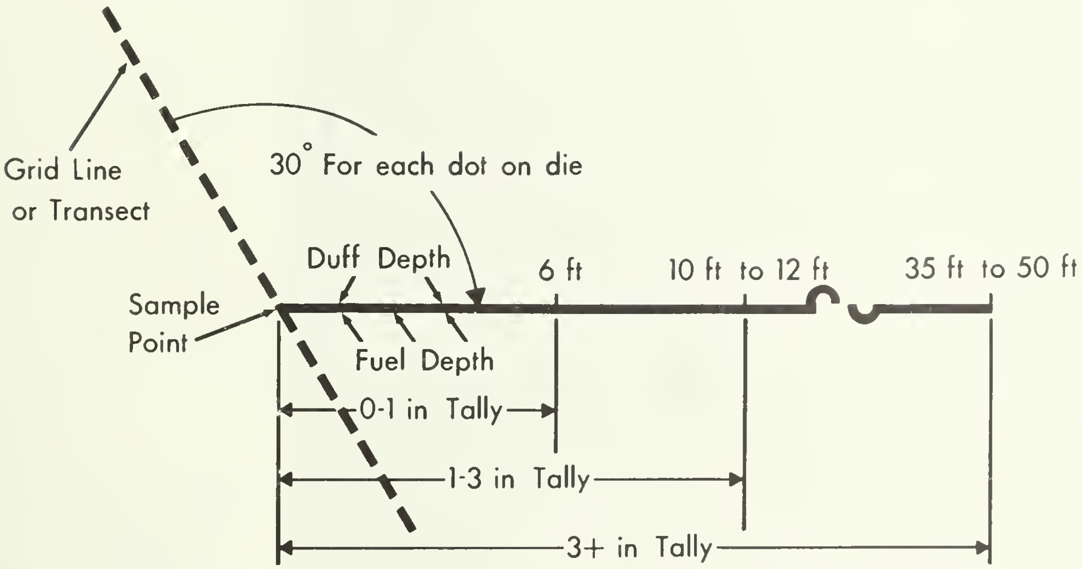


Figure 2.--Top view of sampling plane and location of fuel depth measurements.

Step 4: *Measure or estimate slope* by sighting along the sampling plane from the sample point using an Abney level or similar device. Ample precision is the nearest 10 percent, which can be coded using one digit (10 percent = 1, 90 percent = 9, etc.).

Step 5: *Tally the number of particles* that intersect the sampling plane by the following size classes:

0 to 0.24 inch (0 to 0.6 cm)

0.25 to 0.99 inch (0.6 to 2.5 cm)

1.0 to 2.99 inches (2.5 to 7.6 cm)

The intersections can be counted one size class at a time or "dot tallied," which takes slightly longer than counting (see sample data form, page 14).

The actual diameter of the particle at the point of intersection determines its size class. A go-no-go gage with openings 0.25 inch, 1 inch, and 3 inches works well for separating borderline particles into size classes and for training the eye to recognize size classes (fig. 3).

The vertical plane is a plot. Consequently, in counting particle intersections, it is very important to visualize the plane passing through one edge of the plot rod and terminating along an imaginary fixed line on the ground. *Once visualized on the ground, the position of the line should not be changed while counting particles* (fig. 4). See tally rules for qualifying particles.

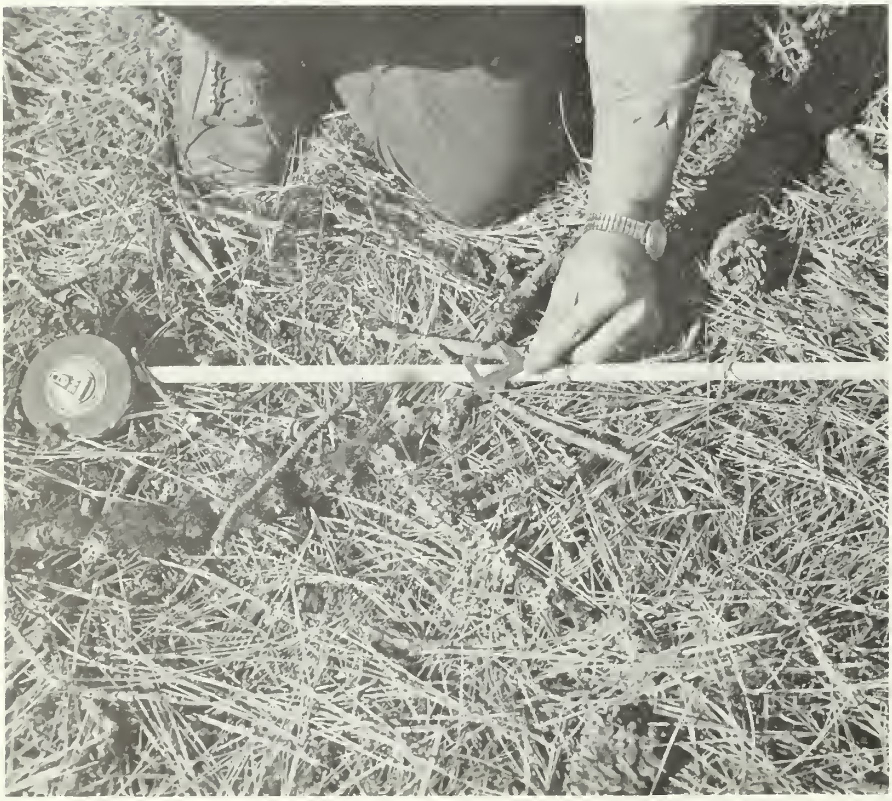
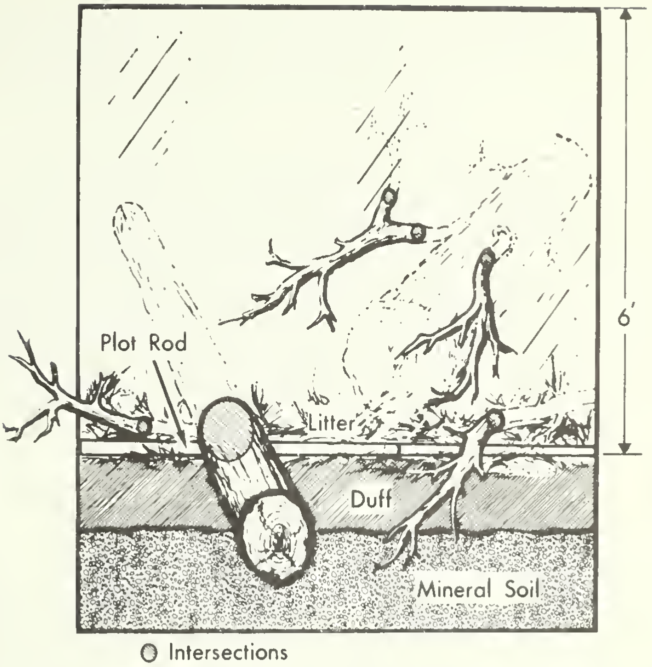


Figure 3.--Diameter of the intersected twig is checked with a go-no-go gage. The plot rod marks the sampling plane.

Figure 4.--The sampling plane is exactly defined by one edge of the plot rod.



Step 6: *Take three measurements of dead fuel depth.* Record depth as the vertical distance from the bottom of the litter layer to the highest intersected dead particle for each of three adjacent 1-foot-wide vertical partitions of the sampling plane (fig. 5). Litter is the surface layer of the forest floor and consists of freshly fallen leaves, needles, twigs, bark, and fruits. Begin the vertical partitions at the sample point. Record to the nearest whole inch.

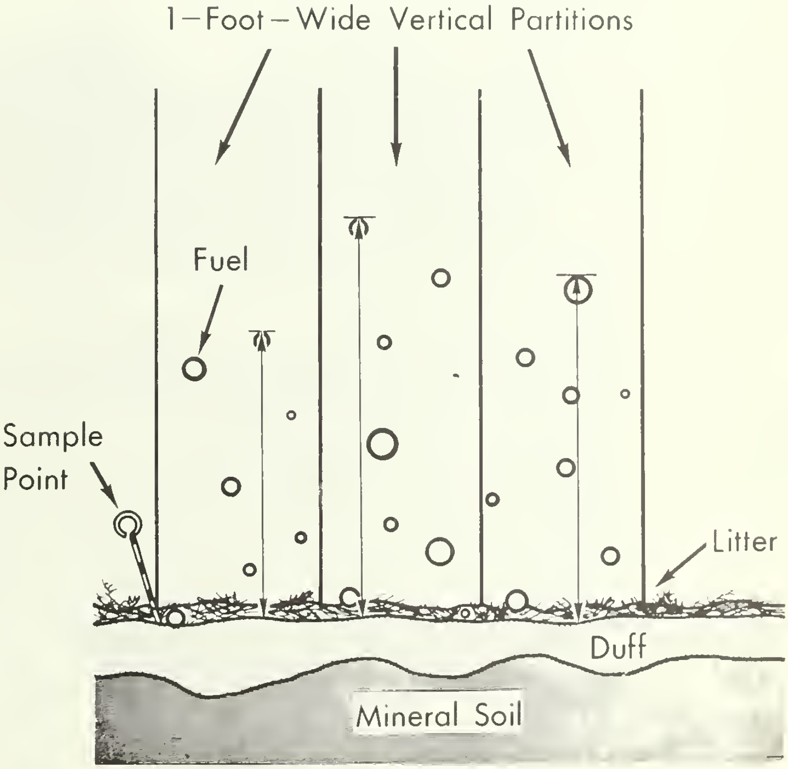


Figure 5.--Cross section of a fuel bed. Depth is measured along the arrows in each 1-foot-wide partition.

Depth should be measured from only those particles included in the inventory for loading. For example, particles acceptable for measurement by the planar intersect technique are also acceptable for determining depth. If other techniques are used to estimate weight per acre of grass and forbs, this vegetation would also qualify for determining depth.

Step 7: *Measure vertical depth of duff* to the nearest 0.1 inch using a ruler along the sampling plane at two points: (1) 1 foot from the plot center; and (2) a fixed distance of 3 to 5 feet from the first measurement.

Duff is the fermentation and humus layers of the forest floor. It does not include the freshly cast material in the litter layer. The top of the duff is where needles, leaves, and other castoff vegetative material have noticeably begun to decompose. Individual particles usually will be bound by fungal mycelium. When moss is present, the top of the duff is just below the green portion of the moss. The bottom of the duff is mineral soil.

Carefully expose a profile of the forest floor for the measurement. A knife or hatchet helps but is not essential. Avoid compacting or loosening the duff where the depth is measured.

When stumps, logs, and trees occur at the point of measurement, offset 1 foot perpendicular to the right side of the sampling plane. Measure through rotten logs whose central axis is in the duff layer (fig. 6).

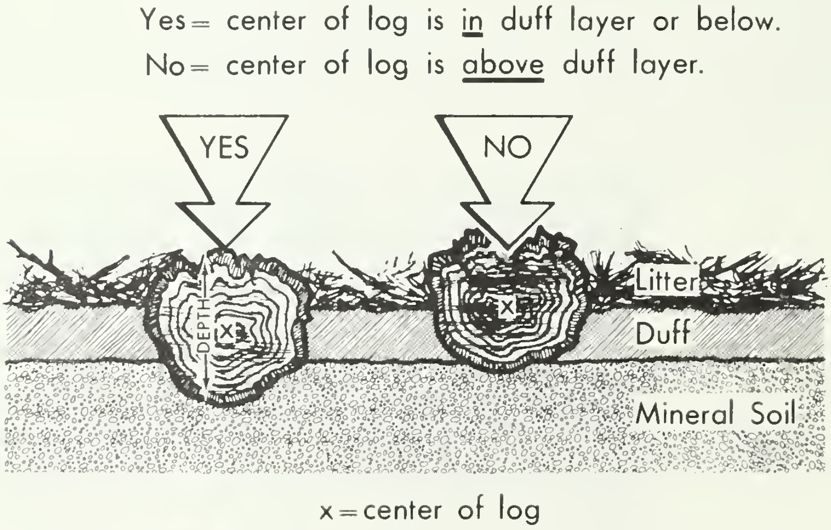

Yes = center of log is in duff layer or below.
No = center of log is above duff layer.
YES
NO
DEPTH
X
X
Litter
Duff
Mineral Soil
x = center of log

Figure 6.--Duff depth is measured through a rotten log when its central axis lies in or below the duff.

Step 8: *Measure or estimate the diameters* of all pieces 3 inches in diameter and larger that intersect the sampling plane. Measure the diameters at the point of intersection to the nearest whole inch.

Record diameters separately for rotten and nonrotten pieces. Consider pieces rotten when the piece at the intersection is obviously punky or can be easily kicked apart.

A ruler laid perpendicularly across a large piece of fuel works satisfactorily for measuring diameter. Be sure to avoid parallax in reading the ruler. Calipers also work well for measuring diameter. A diameter tape, however, is unsatisfactory for pieces in contact with the ground.

Use as many consecutive lines on the data form (see page 14) as necessary to record diameters.

Step 9: *For the entire sample area, record the predominate species* of the 0- to 1-inch-diameter branchwood. An average diameter for the 0- to 0.25-inch, and 0.25- to 1-inch size classes will be selected from this information. If several species comprise the downed debris, estimate the proportion of the two or three most common species. Base this estimate on a general impression of what exists on the sample area and record as percentages of total 0- to 1-inch branchwood. Or, for a slight reduction in accuracy, omit this step and in the calculations use an average diameter for a composite of species (page 16).

TALLY RULES

The following rules apply to downed woody pieces of all diameters:

1. Particles qualifying for tally include *downed, dead* woody material (twigs, stems, branches, and bolewood) from trees and shrubs. Dead branches attached to boles of standing trees are omitted because they are not downed vegetation. Consider a particle downed when it has fallen to the ground or is severed from its original source of growth. Cones, bark flakes, needles, leaves, grass, and forbs are not counted. *Dead woody stems and branches still attached to standing brush and trees are not counted.*

2. Twigs or branches lying in the litter layer and above are counted. However, they are not counted when the intersection between the central axis of the particle and the sampling plane lies in the duff (forest floor below the litter) (fig. 7).

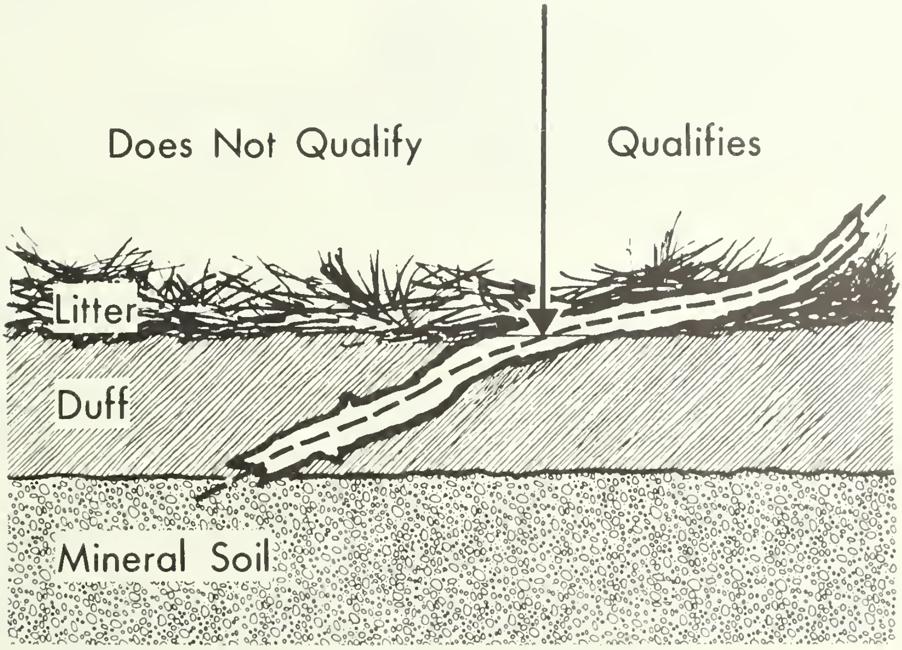


Figure 7.--Regardless of size, pieces are tallied only when intersection lies in and above the litter (right of arrow).

3. If the sampling plane intersects the end of a piece, tally only if the central axis is crossed (fig. 8). If the plane exactly intersects the central axis, tally every other such piece.

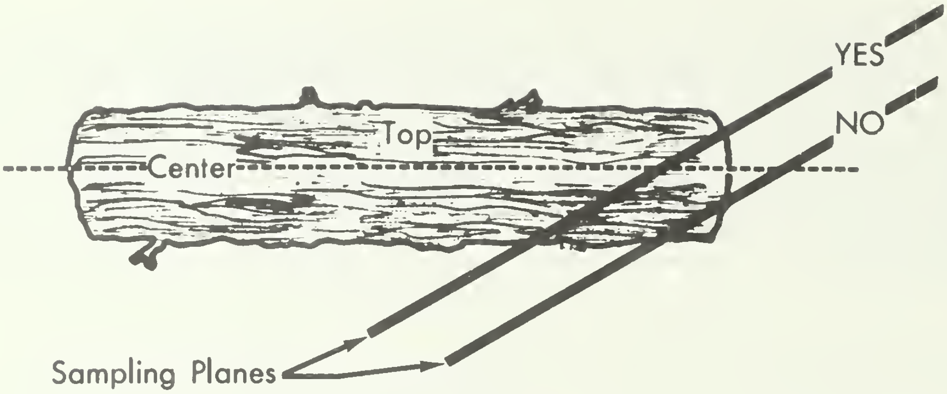


Figure 8.--An intersection at the end of a branch or log must include the central axis to be tallied.

4. Don't tally any particle having a central axis that coincides perfectly with the sampling plane. (This should rarely happen.)

5. If the sampling plane intersects a curved piece more than once, tally each intersection (fig. 9).

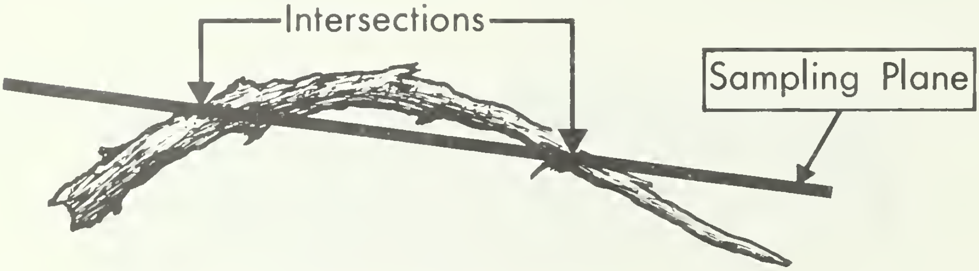


Figure 9.--Count both intersections for a curved piece.

6. Tally wood slivers and chunks left after logging. Visually mold these pieces into cylinders for determining size class or recording diameters.

7. Tally uprooted stumps and roots not encased in dirt. For tallying, consider uprooted stumps as tree boles or individual roots, depending on where the sampling planes intersect the stumps. Do not tally undisturbed stumps.

8. For rotten logs that have fallen apart, visually construct a cylinder containing the rotten material and estimate its diameter. The cylinder will probably be smaller in diameter than the original log.

9. Be sure to look up from the ground when sampling because downed material can be tallied up to any height. A practical upper cutoff is about 6 feet. However, in deep slash it may be necessary to tally above 6 feet.

When standing trees are inventoried along with downed material, it is necessary to fix a limit above the ground for sampling downed material. An upper limit helps define a downed tree so that inventory of standing and downed materials will not overlap.[1]

HEAVY SLASH OPTIONS

1. A yardstick attached to a Jacob's staff is useful for marking the sampling plane and speeds the counting of small particles (fig. 10). Erect the Jacob's staff at the sample point. Aline the yardstick with the direction of the sample plane and level it using an attached bubble level.

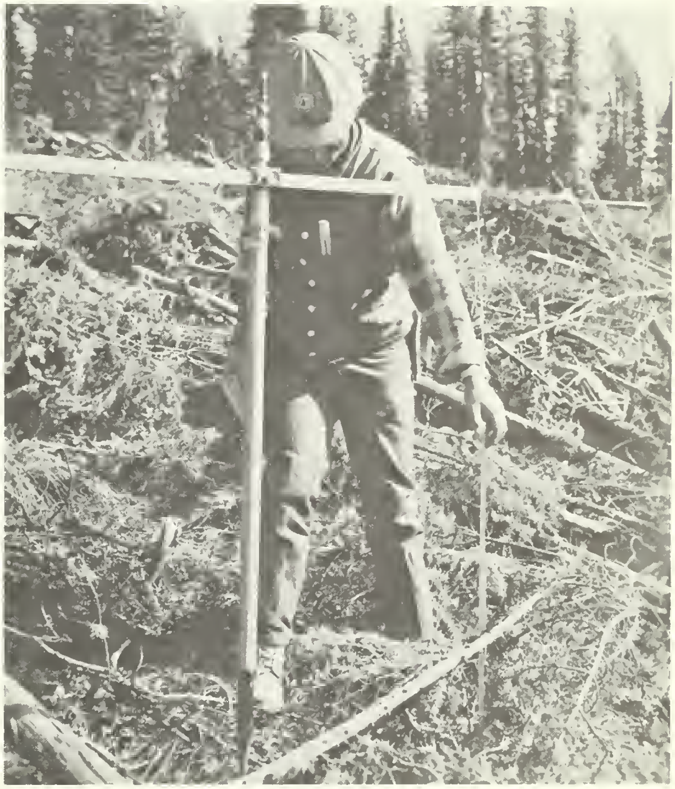


Figure 10.--A yardstick or meter stick attached to a Jacob's staff defines the sampling plane in heavy slash.

2. In areas with considerable slash, sampling efficiency is improved by ocularly estimating the number of 0- to 0.25-inch intersections and actually counting the number of intersections at a subsample of points. The ocular estimates are adjusted using the ratio of ocular estimates-to-actual counts. This method, incorporating 3P sampling, is described in detail by Beaufait and others (1974).

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[1] In the USDA Forest Service Northern Region, a rule has been established that a stem is "downed" and thus qualifies for tallying when the intersection of the sampling plane and central axis is 6 feet or less from the ground. If the midpoint of the bole is more than 6 feet above ground for trees encountered in fixed and variable radius plots, they are inventoried as "standing."

3. For each sampling plane, estimate the proportion of 0- to 1-inch-diameter branchwood to the nearest 10 percent for the three most common species.

UTILIZATION OPTIONS

For pieces over 3 inches in diameter, the following additional measurements can be useful for describing utilization potential:

1. Species
2. Length of piece
3. Diameter at large end
4. Degree of checking, rot, and other defects that apply to the entire piece.

Field Equipment

Item	*Use*
1. Hand compass	Transect and plot layout.
2. Gaming die	Random orientation of sampling planes.
3. 50-foot tape or string and one chaining pin	Delineate the sampling planes.
4. Plot rod	Delineate sampling planes and if calibrated, measure fuel depth.
5. Go-No-Go gage (fig. 11)	Determine size class of borderline particles.
6. 1-foot ruler or steel pocket tape	Measure duff depth and diameters of pieces over 3 inches. Fuel depth could be measured with steel pocket tape.
7. Hypsometer with percent scale	Slope measurement.
8. Sample forms	Record data.
9. For slash: Jacob's staff with attached yard or meter stick and level	Delineate sampling plane for counting small particles.

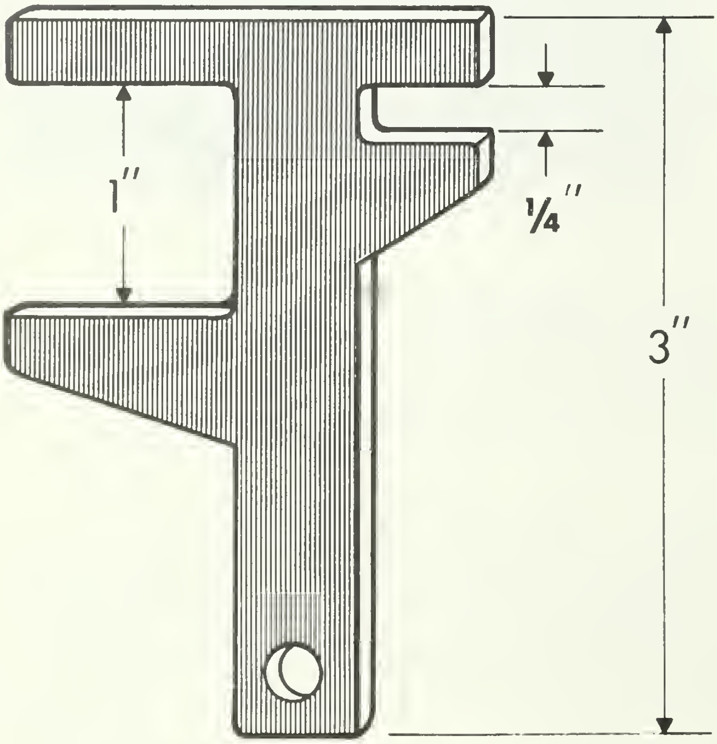

Figure 11.--A Go-No-Go gage can be cut from 1/16 or 1/8-inch sheet aluminum. Cut the notches slightly tight and file smooth to final dimensions.

CALCULATIONS

The calculations can be readily processed by computer[2] and are also easy using a desk calculator. Sample calculations are shown in figures 12 and 13. For a given stand or sample area, fill in the computation summary sheet as follows:

1. Calculate the average slope correction factor (c) using slope correction factors for each sampling plane. Look up the correction factors in table 1 or compute them by:

$$c = \sqrt{1 + \left(\frac{\text{Percent slope}}{100}\right)^2}$$

No slope correction is needed for samples taken using the Jacob's staff.

Table 1.--*Slope correction factors for converting weight/acre on a slope basis to a horizontal basis*

Slope	Correction factor	Slope	Correction factor
Percent	*c*	*Percent*	*c*
0	1.00	60	1.17
10	1.00	70	1.22
20	1.02	80	1.28
30	1.04	90	1.35
40	1.08	100	1.41
50	1.12	110	1.49

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[2] Card punching instructions and a FORTRAN program for computing the inventory results are available upon request from the Northern Forest Fire Laboratory, Drawer G, Missoula, Montana 59801.

DOWNED FUEL INVENTORY

FOREST		SUBCOMPARTMENT	-	ASPECT	
BLOCK		STAND		COVER TYPE	
COMPARTMENT		ELEVATION		HABITAT TYPE	

SIZE CLASS (In.) :	0 - 1	1 - 3	3+
LENGTH OF SAMPLING PLANE (Ft.) :	6	10	35

		NO. OF INTERSECTS			DUFF DEPTH		3+ DIAMETER						FUEL DEPTH		
Plot No.	Slope	0 - .25"	.25 - 1"	1 - 3"	First	Second	Sound	Sound	Sound	Rotten	Rotten	Rotten	First	Second	Third
1	3	24	9	3	11	17	10	3	8			25	10	0	3
1									12						
2	5	8	2	0	8	9						12	18	7	2

If heavy slash, code 1 :

GROUND FUEL COMPOSITION	
Species	*Percent*
1.	
2.	
3.	

Figure 12.--Sample data form.

DOWNED WOODY MATERIAL COMPUTATION SUMMARY

FOREST:__________ COMPARTMENT:__________ STAND:__________

Formulas to compute tons/acre:

(A) 0- to 3-inch material:

$$= \frac{11.64 \times n \times d^2 \times s \times a \times c}{N\ell}$$

(B) 3+-inch material :

$$= \frac{11.64 \times \Sigma d^2 \times s \times a \times c}{N\ell}$$

Size class	Constant	n	d^2	s	a	c	$N\ell$	Tons/ acre	
0 - .25	11.64	32	.0151	.48	1.13	1.08	12	.275	I
.25 - 1	11.64	11	.289	.48	1.13	1.08	12	1.81	II
1 - 3	11.64	3	2.76	.40	1.13	1.08	20	2.35	III
		Σd^2 for 3+							
3+ Sound	11.64	317		.40	1.0	1.08	70	22.8	IV
3+ Rotten	11.64	769		.30	1.0	1.08	70	41 4	V
				3+ Sound & Rotten = IV + V =				64.2	VI
				Total = I + II + III + VI =				68.6	VII

	Sum of 3+-inch diameters	Number of pieces	Average diameter
Sound :	33	4	8.25 in.
Rotten :	37	2	18.5 in.

Sum of duff depths: : 4.5 in.

Number observations : 4

Average duff depths : 1.1 in.

Sum of fuel depths : 40 in.

Number observations : 6

Average fuel depths : 6.7 in.

Figure 13.--Computation summary sheet. The input values are from figure 12.

2. Total the number of intersections (n) over all sample points for each of the 0- to 0.25-inch, 0.25- to 1-inch, and 1- to 3-inch size classes.[3]

3. From table 2, enter the appropriate squared average diameters (d^2) for each size class on the computation sheet. If species composition has been determined, calculate an average d^2 as:

$$d^2 = \frac{P_1 d^2{}_1 + P_2 d^2{}_2 + P_3 d^2{}_3}{P_1 + P_2 + P_3}$$

Where P_1, P_2, and P_3 are percentages for composition of the species recorded in Step 9 (page 9).

If several species are present and their composition unknown, the composite d^2 values can be used as approximate averages.

Table 2.--*Squared average-quadratic-mean diameters for nonslash and slash ground fuels*

Size class (inches)	Nonslash		Slash	
	Cover type[1]	Average d^2	Species[1]	Average d^2
		Inches^2		*Inches*^{2}
0 - 0.25	PP	0.0342 [illegible]	PP, LP	0.0248 .157
	LP	.0201 [illegible]	L	.0149 .122
	S, DF, AF, C	.0122 [illegible]	DF, GF, C, S	.0122 .110
	L	.0149 .122	Composite[2]	.0151 .123
	Composite	.0151 [illegible]		
0.25 - 1	LP	.344 [illegible]	PP, C	.317 .5[illegible]
	S, DF, AF, C	.304 .55[illegible]	DF, GF, LP, L, S	.278 .527
	L, PP	.238 [illegible]	Composite	.289 .538
	Composite	.289 .538		
1 - 3	PP, AF	3.12 1.77	LP	3.50 1.87
	S, DF, C, LP	2.87 1.69	DF, PP, GF	2.83 1.68
	L	2.17 1.41	L, C, S	2.30 1.52
	Composite	2.76 1.[illegible]	Composite	2.76 1.66

[1] PP=ponderosa pine (*Pinus ponderosa*); LP=lodgepole pine (*Pinus contorta*); S=Engelmann spruce (*Picea engelmannii*); DF=Douglas-fir (*Pseudotsuga menziesii*); L=western larch (*Larix occidentalis*); GF=grand fir (*Abies grandis*); C=western redcedar (*Thuja plicata*); AF=subalpine fir (*Abies lasiocarpa*).

[2] All composite values are averages of nonslash and slash fuels with each cover type and species weighted equally.

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[3] For calculating standard errors of the estimate, the number of intersections (Step 2) and the sum of squared diameters (Step 7) must be recorded for each plot.

4. Determine specific gravity(s) of materials from known sources or from laboratory studies. Approximate specific gravities for conifers are:

Diameter class (*inches*):	0-0.25	0.25-1	1-3	3+Sound	3+Rotten
Specific gravity :	0.48	0.48	0.40	0.40	0.30

Decay and variability in density make this variable difficult to handle with accuracy. More accurate estimates for large sound material can be obtained by using specific gravities from the USDA Forest Service (1955) *Wood Handbook*. Special studies, as shown in Appendix II, are needed to improve accuracy for the other particle categories.

5. For slash, determine the nonhorizontal angle correction factors (a) from table 3. For nonslash fuels, use the following correction factors based on a composite of western species:

0 to 3 inches: 1.13

3+ inches: 1.00

The correction factor adjusts weight estimates for the fact that all particles do not lie horizontally as assumed in the planar intersect theory.

Table 3.--*Average secant of nonhorizontal particle angles for correcting orientation bias for slash*

Size class (*inches*)	Species[1]	Average (a) Fresh slash	Average (a) 1-year and older slash
0 to 0.25	PP	1.25	1.25
	Others	1.40	1.15
0.25 to 1	PP	1.25	1.25
	Others	1.13	1.13
1 to 3	PP	1.22	1.22
	Others	1.10	1.10
3+	All (an assumption)	1.00	1.00

[1] PP=ponderosa pine; Others=based on data for Douglas-fir, lodgepole pine, Engelmann spruce, western redcedar, western larch, and grand fir.

6. Calculate the total length of sampling line (Nℓ) for each size class: Nℓ = number of sample points multiplied by length of sampling plane (feet).

7. For material 3 inches and larger, square the diameter of each intersected piece and sum the squared values (Σd^2) for all pieces in the sampled area.[4] Compute

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[4] *Ibid.*

Σd^2 separately for sound and rotten categories. To obtain weights or volumes for certain diameter ranges (3 to 9 inches, for example), compute Σd^2 for the specified range.

8. Calculate the sum of diameters for all intersected pieces 3 inches and larger (calculate sound and rotten materials separately).

9. Calculate the sum of all measurements for duff depth.

10. Calculate tons/acre, using formulas on the computation sheet (fig. 13).[5] If desired, calculate volumes:

$$\text{Cubic feet per acre} = \frac{32.05 \times \text{tons per acre}}{\text{Specific gravity}}$$

11. Calculate average diameters of intersected pieces 3 inches and larger.

12. Calculate average fuel depth and duff depth as the sum of the depths divided by the number of measurements.

13. Appendix III shows how to calculate needle quantities in slash.

When inventorying large areas that hold many species it is practical to use composite values and approximations for diameters, specific gravities, and nonhorizontal corrections. For example, a timber management and downed-debris inventory in the Northern Region of the USDA Forest Service utilizes composite average diameters, composite average nonhorizontal correction factors, and best approximations for specific gravities.

For the Northern Region inventory, the formulas in figure 13 simplify to:

1. 0- to 0.25-inch size class: $w = 0.09533\ nc/N\ell$
2. 0.25- to 1-inch size class: $w = 1.825\ nc/N\ell$
3. 1- to 3-inch size class : $w = 14.52\ nc/N\ell$
4. 3+-inch sound : $w = 4.656\ \Sigma d^2 c/N\ell$
5. 3+-inch rotten : $w = 3.492\ \Sigma d^2 c/N\ell$

where:

w = weight, tons/acre.

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[5] The formulas incorporate an insignificant bias because n, Σd^2, and c are totaled separately. Summing n × c or $\Sigma d^2 \times c$ over all plots would eliminate the biases; however, this is unnecessarily troublesome.

FURTHER APPLICATIONS

If only debris larger than 3 or 4 inches in diameter is to be inventoried, the line intersect technique described by Howard and Ward (1972) and Bailey (1969) might be more appropriate than the planar intersect method, especially in logging slash. The line intersect method employs a few long sampling planes; the planar intersect method employs many small sampling planes. If debris both greater than and less than 3 or 4 inches in diameter must be inventoried, the planar intersect technique is more efficient. The planar intersect technique can also be coordinated with other measurements of vegetation taken on plots (for example, an inventory of timber volume).

The procedures in this Handbook can be applied to downed debris in areas other than the western United States by assuming or measuring average diameters for the three size classes of particles. Average diameters have been determined for red pine *(Pinus resinosa)*, jack pine (*Pinus banksiana*), and oak (*Quercus* spp.) (Brown and Roussopoulos 1974). A convenient method for estimating slash weights of several Lake States tree species has been reported by Roussopoulos and Johnson (1973).

If fire behavior is to be mathematically modeled using models such as Rothermel's (1972), weights of other fine fuels such as needle litter, dead grass, and dead forbs also should be determined by sampling or by extrapolating from existing information. Sampling for quantities of grass, forbs, and litter requires methods other than the planar intersect technique (USDA Forest Service 1959; Brown 1966; Hutchings and Schmautz 1969).

Because practical methods of inventory have been lacking in the past, accumulations of downed fuel and debris have been described in vague terms such as "light," "medium," and "heavy." Using the simple field procedures in this Handbook, weight and volume of downed woody material can be inventoried to provide an objective basis for managing debris.

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APPENDIX I

Sampling Intensities

NUMBER AND SIZE OF SAMPLING PLANES

Sampling precision can be controlled by altering the number of plots and length of sampling planes. As a general rule, the more downed material on an area, the fewer the number and shorter the length of sampling planes required to achieve a given level of precision. Figure 14, based on average sampling variation for number of intersections of 0- to 1-inch and 1- to 3-inch particles, can help in choosing number of plots and length of sampling planes. The data for figure 14 are from many stands of varying composition and downed debris accumulations in northern Idaho and western Montana. Curves for all material under 3 inches in diameter would fall between those for the 0- to 1-inch and 1- to 3-inch classes.

Percent errors of 20 percent or less are probably adequate levels of precision for assessing most fuel problems. Percent error is the standard error of the estimate divided by the mean estimate and expressed as a percentage. More precision, such as percent errors of 10 to 15 percent, may be desirable for evaluating utilization potential of downed woody material.

Precision is maximized using a different length of sampling plane for each size class. However, considering both field effort and precision, it is more efficient to use the same plane length for sampling the 0- to 0.25- and 0.25- to 1-inch classes. The following suggestions will help determine the most efficient number and length of sampling planes for a given area:

1. Record data from about 20 sampling planes in an area and calculate the variation for guiding further sampling.

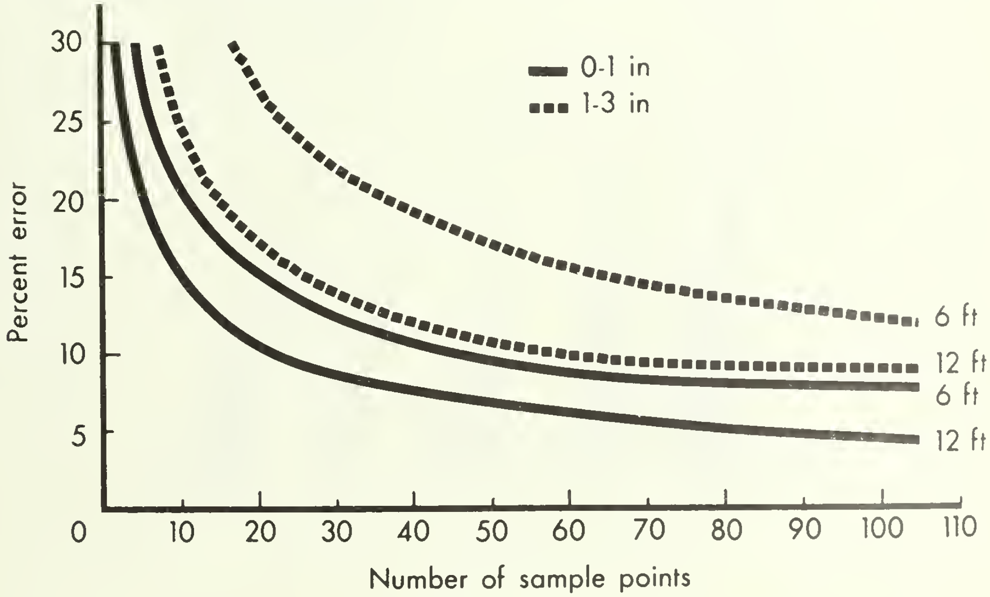

Figure 14.--Percent errors for number of particle intersections along 6- and 12-foot-length sampling planes related to number of sample points for quantities of light slash and nonslash. Percent error is 100X (standard error of the estimate divided by the mean estimate).

2. For material larger than 3 inches in diameter, the sampling plane should be long enough so that on the average at least one intersection occurs with three-fourths or more of the planes. A large sampling variance results when many zeros are recorded for intersections. In areas where very little downed material exists, sampling planes should actually be one to several hundred feet long to provide respectable precision. Where many sampling planes have zero entries, other methods such as measurement of length and diameter of all downed pieces may be the most efficient method of inventory.

3. The number and length of sampling planes should be chosen so that for a piece size of interest, such as material over 3 inches in diameter, at least 35 to 50 intersections occur over an entire sampled area.

SAMPLING PRECISION FOR DEPTH MEASUREMENTS

To achieve percent errors of 15 and 20 percent using two-stage sampling, the most efficient number of secondary sampling units appears to be three for fuel depth and two for duff depth (fig. 15).

The data for figure 15 represent average variation from sampling a wide variety of forest and downed fuel conditions in northern Idaho and western Montana. Several thousand measurements were taken using two secondary sample points for duff depth and three secondary sample points for fuel depth. Vegetation qualifying for fuel depth measurements included all dead downed woody material and dead brush, grass, and forbs. The data were subjected to analysis of variance for two-stage sampling.

The number of sample plots required to attain a given level of precision varies considerably among different areas. For choosing sampling intensities for specific areas the number of primary sample points in figure 15 could be adjusted up or down considerably, depending on homogeneity of the dead vegetation strata.

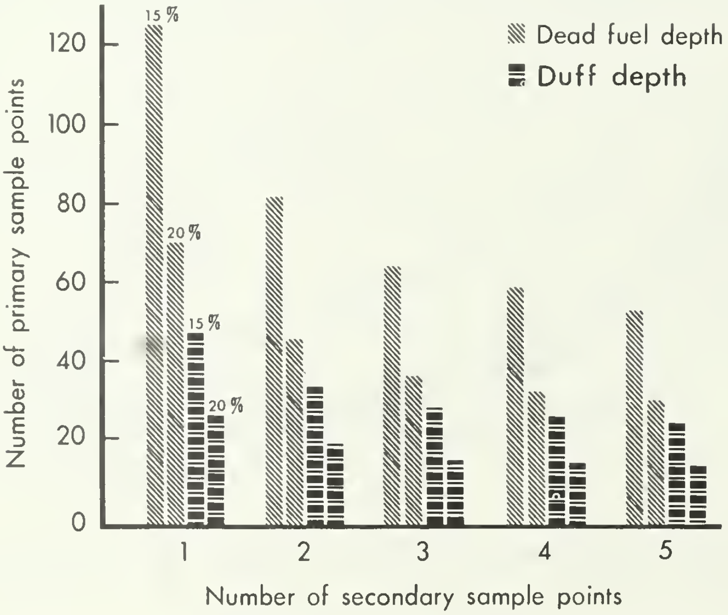

Figure 15.--Number of primary and secondary points needed to achieve percent errors of 15 and 20 percent for fuel depth and duff depth.

APPENDIX II

Specific Gravities of Sound Material

The specific gravities in table 4 are based on ovendry weight and airdry volume and can be used for calculation of loadings.

Table 4.--*Specific gravity of woody twigs and branches with bark attached*

Species	Diameter size class (cm)				
	[1]0 - 1	[1]1 - 10	[2]0 - 1	[2]1 - 3	[2]3 - 5
Ponderosa pine	0.41	0.51	0.57	0.53	0.49
Douglas-fir	.55	.43	.56	.56	.52
Western larch	.46	.55			
Lodgepole pine	.49	.41			
Engelmann spruce	.34	.34			
Subalpine fir	.41	.40			
Western redcedar	.48	.33			

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[1] William R. Beaufait and Charles E. Hardy. Fire quantification for silvicultural use. USDA For. Serv., Intermt. For. & Range Exp. Stn. (In preparation.)

[2] Brown (1972).

APPENDIX III

Calculating Needle Quantities

Weight of needles can be determined by multiplying ratios of needle-to-branchwood weights (table 5) times estimated branchwood weight. The estimates in table 5 are for branches having all needles attached. The data are based on estimates of needles and branchwood from total living crowns for trees between 2 and 30 inches d.b.h.

Table 5.--*Foliage-to-branchwood ratios based on ovendry weight*

Species	Diameter of branches		No. trees sampled
	0- to 0.25-inch	0- to 1-inch	
Western larch	0.70	0.43	13
Ponderosa pine	14.10	.98	14
Western white pine	3.30	1.02	5
Douglas-fir	2.19	.82	9
Western hemlock	1.90	.80	17
Engelmann spruce	2.38	1.34	4
Western redcedar	5.00	1.45	13
Lodgepole pine[1]	1.34	.31	3
Grand fir[1]	2.52	1.00	3

[1] Data by Fahnestock (1960).

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SNOW CACHE SEEDLING STORAGE: SUCCESSFUL SYSTEMS

Allen K. Dahlgreen, Russell A. Ryker, and David L. Johnson

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CONTENTS

Page

INTRODUCTION 1

STORAGE AND HANDLING REQUIREMENTS 2

CACHE LOCATION AND PLANNING 2

THE PIT SNOW CACHE 4

THE CULVERT SNOW CACHE 7

TREE HANDLING 8

SUMMARY 12

ABSTRACT

Good survival and growth of planted seedlings have been experienced in the Intermountain Region, USDA Forest Service, when proper snow cache planning, construction, and related tree handling techniques are practiced. General snow storage and handling requirements are described, and planning and construction details are provided for two types of snow caches that have been used successfully for several years by the Payette National Forest in west-central Idaho. The pit snow cache has been the prescribed seedling storage method for the Intermountain Region since 1970. The culvert snow cache also is a field-proven system. The report includes recommendations applicable to both systems and others for proper pre- and post-storage care of seedlings.

INTRODUCTION

Successful reforestation by tree planting requires meticulous planning and care at each step. Proper attention to the storage and handling portion of the process will not insure success if all other steps are not equally well done. However, seedling storage and handling often are slighted in reforestation programs, being relegated to untrained persons using inadequately planned facilities. Improvements in this phase of the process, therefore, are critical to improved programs.

The techniques described here have been an important part of most successful reforestation programs in the Intermountain Region in recent years. Numerous instances have been recorded in the Region where trees stored in snow caches for 60 to 90 days or more, and handled as described, have responded with first-year survival of 90 percent or more and good initial growth.

In 1973, more than 95 percent of the 6.9 million trees planted in the Region were stored in snow caches. The average first-year survival of all trees planted was 88 percent. Species included ponderosa pine, Jeffrey pine, lodgepole pine, Douglas-fir, western larch, and Engelmann spruce.

Snow caches have been used to store tree seedlings in the Intermountain Region nd elsewhere for many years. Results have varied according to snow cache design, or ack of it, and pre- and post-storage tree handling. A recent study[1] indicated that roperly constructed snow storage facilities provide a good temperature regimen for lanting stock over extended periods. Temperatures measured within the root mass of ackaged trees stored in two types of snow caches were actually lower, and fluctuated ess, than those measured in similarly packaged trees stored in the cooler at Lucky eak Nursery.

This report describes two field-proven snow cache systems, and tree handling rocedures compatible with them. The first type (the pit snow cache) is essentially a it dug in a suitable snowbank, filled with trees, covered over with snow, and insulated. it caches have been used successfully for many years on the Payette National Forest in daho, and elsewhere in the Intermountain Region. The second type (the culvert snow ache), developed by Dave Johnson for the Payette National Forest, utilizes one or more arge culverts placed on site in the fall and allowed to snow in. Early the next spring, rees are placed in the culverts upon arrival from the nursery, and the openings are esealed with snow. This technique has also proven successful with certain types of eedling packages, and where snowfall is adequate.

---

[1] R. A. Ryker, A. K. Dahlgreen, D. Johnson, and F. E. Morby. Snow cache tempera-ures suitable for storage of conifer nursery stock. USDA For. Serv. Res. Note NT-181, 7 p., illus. 1974.

STORAGE AND HANDLING REQUIREMENTS

Experience in the Intermountain Region indicates that a satisfactory seedling storage system must assure that temperatures within the mass of trees being stored are reduced to about 33° to 34°F in a short time, and maintained at that level for 100 days or more. The trees should not be disturbed until just before planting, and injurious influences such as temperature and humidity fluctuations and fungi must be excluded or suppressed by adequate snow barriers. Trees should not be subjected to serious stress while in transit from the nursery or after removal from storage.

Properly located, designed, and protected snow caches meet these storage requirements. Adherence to the handling techniques described will minimize stress and "shock" during transportation and preplanting handling.

CACHE LOCATION AND PLANNING

The general location, timing, and coordination considerations vital to good storage management are equally applicable to pit and culvert caches.

The exact snow cache location should be selected in the fall, particularly if a large volume of trees will be stored. The site should be convenient for the transportation to be used, and adequate snow must be available when the trees arrive. A preferred location is a level area in open shade on a gentle northerly slope. However, the north side of a stand of tall trees, or the north side of a building is satisfactory. Location on a slight rise will avoid the danger of flooding. Locations on south slopes, depressions, or under the dripline of trees (fig. 1) should be avoided.

After being placed in the cache, it is very important that the trees not be disturbed until a day or two before planting.

Use of snow caches for "temporary" storage--when the trees are shifted from cache to cache as snowmelt proceeds to higher elevations--is not recommended. This practice almost invariably results in reduced survival and poor initial growth of survivors. Severe stresses are imposed on the trees by rapid and repeated temperature and humidity fluctuations and handling injuries.

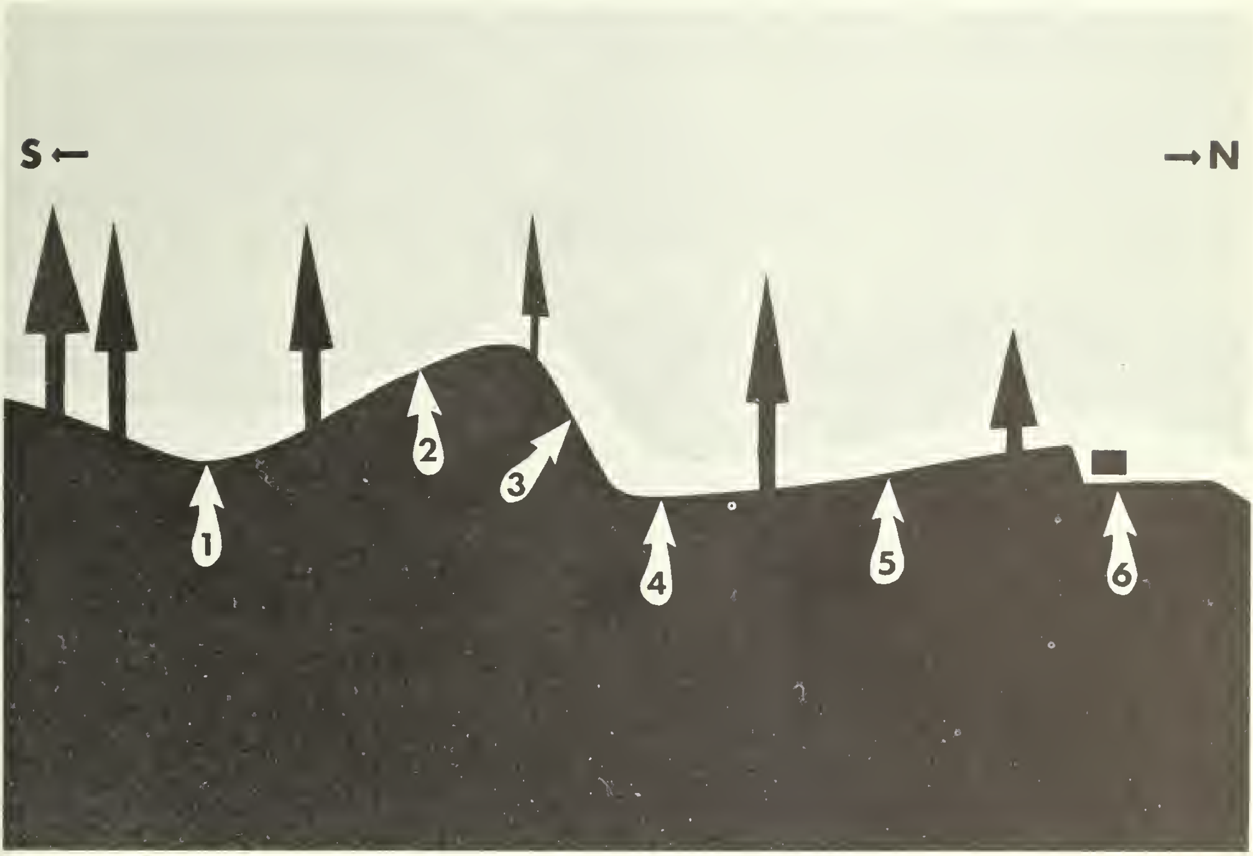

Figure 1.--Locating a snow cache.

Site 1...looks good, but could be bad. During periods of rapid snowmelt, water could accumulate in the low areas, inundating the trees.

Site 2...is on a rather steep south aspect. Snow accumulation is less, will melt early.

Site 3...is a long and very steep slope prone to snow creep or avalanche, which would dislocate the tree cache.

Site 4...is an acceptable location, particularly if an avalanche has already occurred on the adjacent slope.

Site 5...is a good location. Though it has a south aspect, the slope is not steep and there is shade from the existing stand. There is a good snowpack and good drainage.

Site 6...is ideal. In addition to having enough snow, shade, and good drainage, it is next to the road, facilitating the transportation of trees and the equipment to build the cache.

Preparatory work needed the fall before the cache is to be used varies. For a small cache, the only work necessary may be removing large debris from a fairly level area (approximately 1 square yard per thousand trees to be stored) and marking the exact cache location with long poles. Tractor work to clear and level the cache area, prepare turnarounds, and improve access may be required for a cache designed to hold several hundred thousand trees. Insulating material, other supplies, and tools may need to be placed near caches that will receive trees by airdrop or snowmobiles.

A sketch or plan should be made of the cache layout before construction or filling starts to assure that different lots of trees can be easily removed as needed. The plan should be followed closely when loading the cache and extracting the trees for planting to avoid unnecessary disturbance of the trees and conserve time and effort. All trees to be stored in a given cell or culvert section should arrive the same day.

Trees should be placed in snow caches as early in the spring as possible. This may require opening roads. Early cache construction reduces the chance of exposure damage to trees in handling, and assures an adequate volume of snow to bring the tree mass temperatures to the 33° to 34°F range and maintain them there as long as necessary. Snow is more easily worked before its water content is increased by accelerated melting late in the season, and snow lasts better when its water content is below 40 percent.

Close coordination is essential for satisfactory snow cache establishment. The nursery must schedule tree delivery to the cache area or transfer point by dependable truckers, and crews and equipment must be ready with adequate worktime scheduled to receive and store the trees. Poor scheduling may result in reduced survival and growth. Weather conditions must be considered if travel is in remote areas or where blizzard or avalanche conditions are present.

The number of trees to be stored, expected storage period, and snow cache location determine the amount and timing of work required for cache construction.

THE PIT SNOW CACHE

The storage cells in the pit snow cache should be shoveled or plowed out not more than a day or two before the trees are delivered. A level, firmly compacted snow floor no less than 2 feet thick should be provided. There should be no debris between the ground and the floor surface.

Tree packages should be stored in rows. The length of row needed for each lot of trees should be calculated and shown on the plan. Packages of trees should be stacked no more than four high. The rows of trees should be at least 1 foot apart, and the stacks of packages should be 6 inches apart in the rows to hasten cooling and provide circulation.

Cooling is improved and removal of seedlings made easier if two 2 by 4's are placed on edge between the third and fourth layers of packages as shown in figure 2. The timbers may be pulled free when the cache is opened, making it much easier to remove the packages.

Snow should be shoveled into the spaces between rows and stacks and over the top of the packages. Work of loading and shoveling crews should be coordinated on large projects to minimize exposure of the trees. The cache must be closed as soon after it is filled as possible.

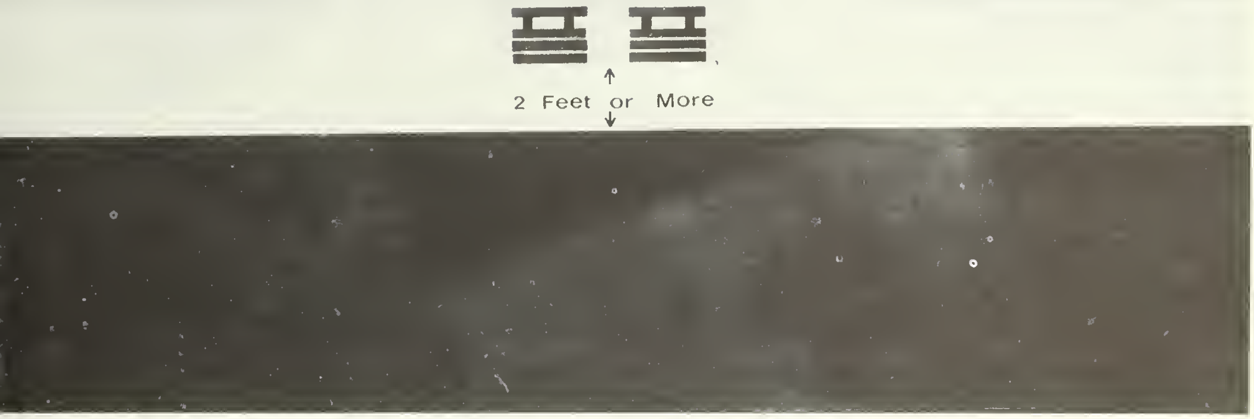

Figure 2.--Arrangements of packages within a pit cache. There should be at least 2 feet of snow between the ground and the trees. Rows of tree packages should be at least 1 foot apart, and the stacks should be 6 inches apart within a row.

Kraft paper or cardboard box seedling packages may be protected from snowmelt by a single sheet of plastic over the top of the cell. The plastic should not extend down around the sides of the cell because this could reduce circulation and cause the trees to spoil.

A thick cover of snow can be dozed onto the cache when enough snow has been shoveled onto the trees to prevent the machine from crushing them. The entry to each cell of trees should be marked with long poles, and snow in this area should not be packed as tightly as in the main body of the cache. Entry will be difficult if the snow is packed hard at access points to be shoveled open in the spring. A powersaw may be used to facilitate cache opening.

A minimum of 4 feet of packed snow should be provided over the trees. The entire cache, and an area of snow surrounding the cache at least equal in width to the total height of the cache should be covered with a 4- to 6-inch layer of sawdust, straw, or shavings. A canvas or other water repellent covering should be placed over the completed cache to prevent rain from accelerating snowmelt (fig. 3).

Local experiences may indicate that larger masses of snow are needed if snow moisture content is high, available insulation materials are of low value, or if storage is to extend beyond mid-June. The snow cache needs no further attention except an occasional inspection to make sure the snow does not melt away in thin spots, and the covering is not removed.

A tarp should be hung over the opening of the cache after it has been opened to prevent heating within the cells (fig. 4).

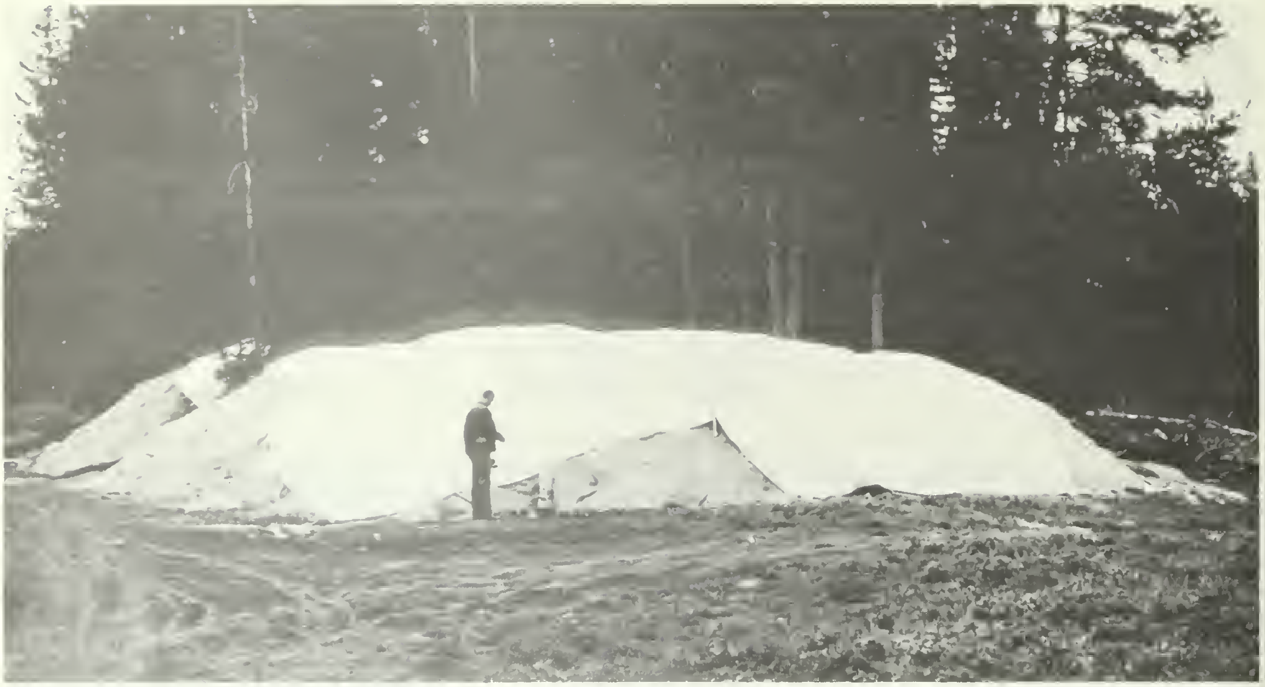

Figure 3.--A completed cache with insulating material and protective covering in place. Properly located and constructed caches remain long after the snow on surrounding terrain has melted. This cache provided satisfactory seedling storage for 3-1/2 months, until mid-July.

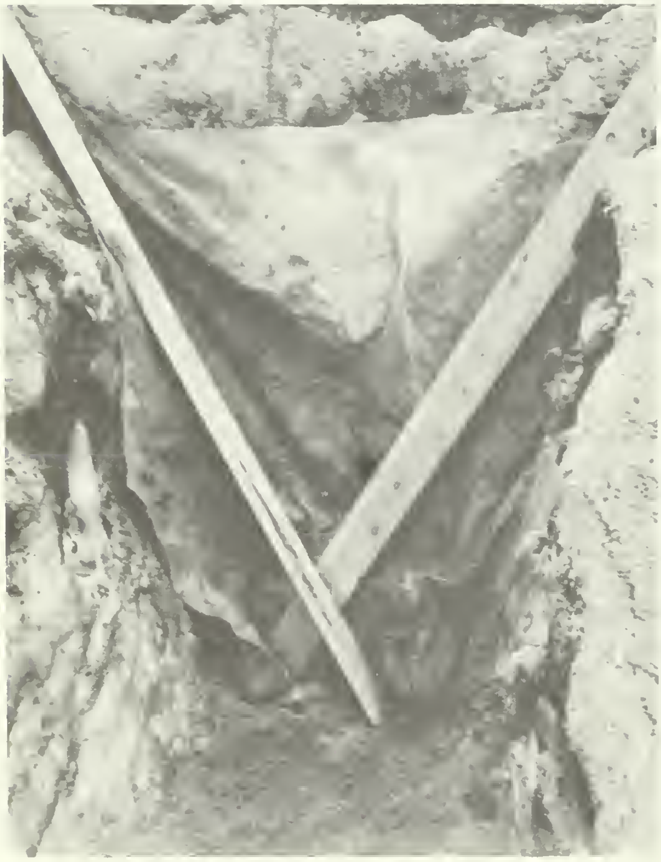

Figure 4.--An opened cache with tarp in place across the opening to prevent a temperature rise within the cache.

THE CULVERT SNOW CACHE

The culvert cache system offers several advantages over the pit snow cache. Expensive plowing through deep snow is not necessary, heavy equipment and large crews are not required, and trees can be stored economically at remote locations. Like the pit cache, the culvert cache is suitable for either large or small volumes of trees. It is not recommended for use with trees packaged in open crates since we have experienced serious drying when using this type of package in culverts. Tests are being made with perforated culverts in an effort to eliminate the drying problem. Good results have been obtained when trees in polyethylene-lined kraft paper bags have been stored in culvert pipes.

Suggested locations for culvert caches are heavy snowfall areas and sites where large drifts accumulate on level ground. Natural snow accumulation must be depended upon for cooling and temperature maintenance.

Pipe culverts to be used for caches must be placed the fall before use. Pipes 5 feet in diameter and up to 20 feet long are reasonably easy to handle and provide good storage and working space. The culvert should be positioned to 2 to 3 feet above the ground on logs or other supports to permit snow to accumulate under it and to prevent surface water seepage into the pipe. The pipe should be blocked up at intervals to prevent bending under the snow load. A system of stringers on log supports, spaced as needed to support anticipated snow loads, (fig. 5) has proven satisfactory.

The ends of the pipe should be marked with long poles to facilitate location in the spring. Insulating and covering materials should be stored in the pipe or nearby where they will be accessible when the snow is deep. A ladder is often useful for getting in and out of the culvert--especially in areas where snow depths range from 10 to 20 feet.

Tree packages can be transported to the storage site by snowmobiles or dropped from aircraft with cargo parachutes. A tree pickup crew equipped with snowmobiles must be on hand to retrieve air-dropped trees and transport them to the cache.

Tree placement in the culvert should provide for air circulation to maintain the desired temperatures. Pieces of 2 by 4's can be used to separate packages of trees in the culvert, or crude racks can be provided.

Entries to the pipe should be closed with snow immediately after the trees are stored, and the area above and around the culvert should be covered with protective materials as described for the pit snow cache. Snow may need to be shoveled over the culvert before insulation is applied if snow depth is marginal.

Other insulating materials may be available for retarding snowmelt, particularly where handling of bulk materials is difficult. Initial trials show that a "basket-weave" arrangement of fiberglass insulation rolls between two sheets of plastic can effectively slow snowmelt, and may be reused if handled carefully. Special care must be taken to assure that wind and gradual changes in the configuration of the snow mound do not cause the insulation to shift, permitting rapid snowmelt. A thick layer of tree boughs may be used as insulation if other materials are not available.

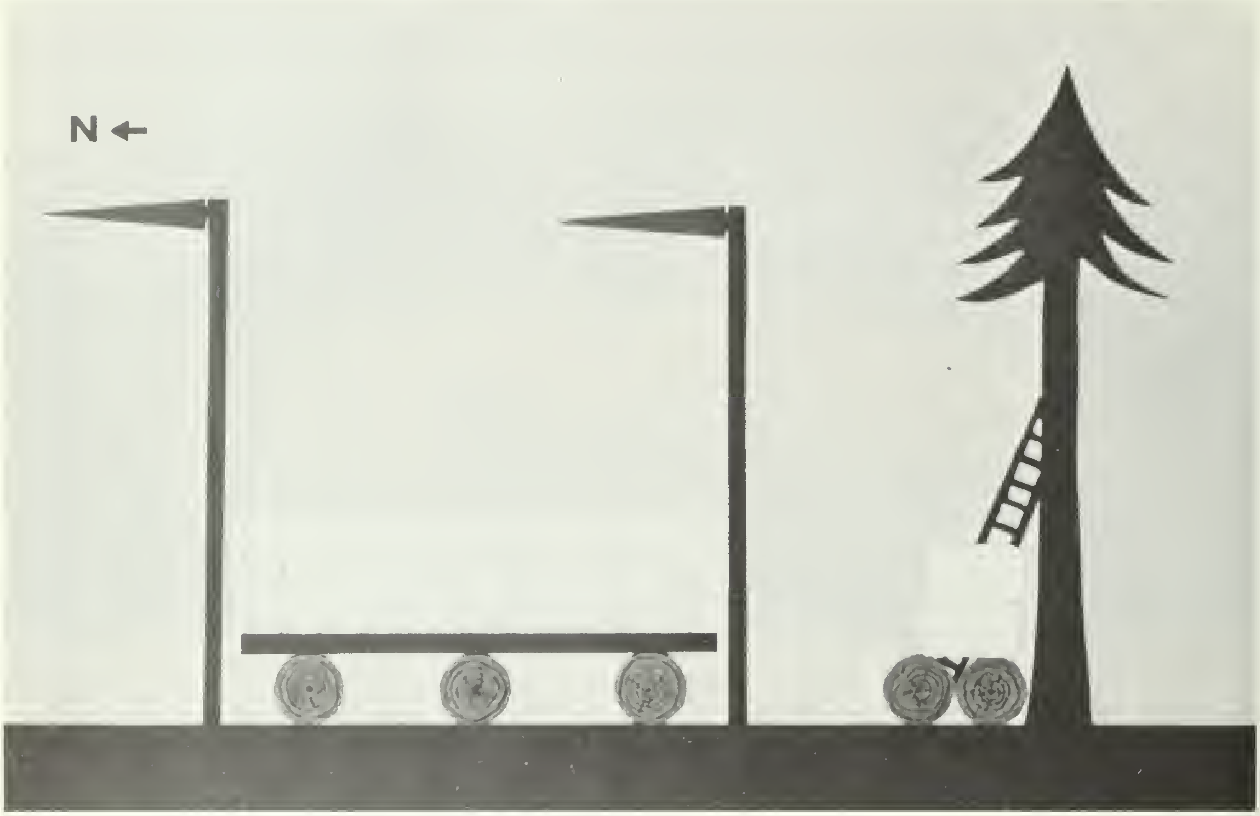

Figure 5.--A culvert pipe positioned 2 to 3 feet above the ground on log supports with stringers to prevent bending. Insulating and covering materials and an access ladder are placed nearby. Long poles with flagging mark each end of the pipe.

TREE HANDLING

Trees should be given a preshipping chill in the nursery cooler to reduce temperatures within the packages to 38°F or less. Trees should be kept refrigerated while in transit from the nursery to the snow caches. Temperature fluctuations in the tree packages while in transit to caches should be held to a minimum.

Temperatures of 50° to 75°F with relative humidities of 15 to 30 percent are common at planting sites in the Intermountain Region. Trees exposed to these conditions shortly after removal from the low temperature-high humidity environment of a snow cache are subjected to severe stresses. The most immediate and apparent response to this is wilting. Eventual responses may include premature needle drop, little or no bud elongation, or death, depending on the severity of the stress.

Correct handling and acclimatization to accustom the trees to the approximate atmospheric and soil conditions prevailing at the planting site will reduce or eliminate these problems, which are common in some degree to all other storage-handling systems.

Trees are considered acclimatized when root zone temperatures in the packages are at or near general soil temperature at a depth of 8 to 10 inches or air temperature, whichever is lowest. Soil thermometers with 12-inch temperature probes are ideal for measuring both soil and tree temperatures.

Trees may be acclimatized at any well-shaded, protected location convenient to both storage and planting areas. They must be covered while in transit, and should not be exposed to heat, sunlight, or drying winds until thoroughly acclimatized. After acclimatization, exposure should be held to a minimum until the trees are planted. Trees being acclimatized should be arranged with the tops exposed, to permit free, but gentle air movement around them. A tent or canvas fly is often used to control air movement. Surrounding areas should be kept moist to reduce stresses while the seedlings are adjusting to atmospheric conditions.

It is essential that an abundance of water be in close contact with the tree roots during the acclimatization period. Standard open-end crates contain an abundance of moist packing material that allows acclimatization before uncrating, but special handling is recommended. This special handling is required to acclimatize trees packed in bags or closed boxes. A satisfactory method is illustrated by figures 6 through 10.

The vermiculite dip-burlap wrapping method allows acclimatization to be completed and the trees to be transported to the planters with minimum stress. The nail must be removed and the burlap loosened slightly to permit easy tree removal when the package is placed in a planting bag or tray.

The time required for acclimatization depends on weather and other conditions at the planting site, but usually trees prepared in the afternoon are ready for planting the next morning. The trees should be in the ground within 12 to 24 hours and no longer than 48 hours after the start of the acclimatization process.

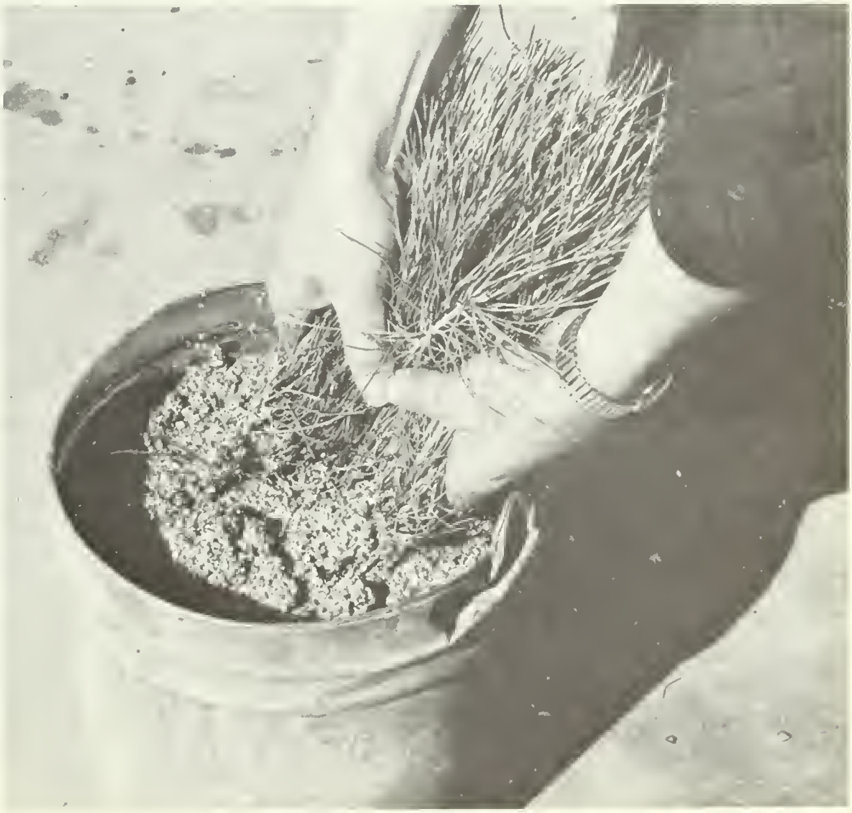

Figure 6.--Step 1: The roots of the trees, a handful at a time, are dipped into a thick slurry of #4 horticultural vermiculite. This coating of wet material clings to the roots, providing moisture and protection during periods of exposure until the trees are planted.

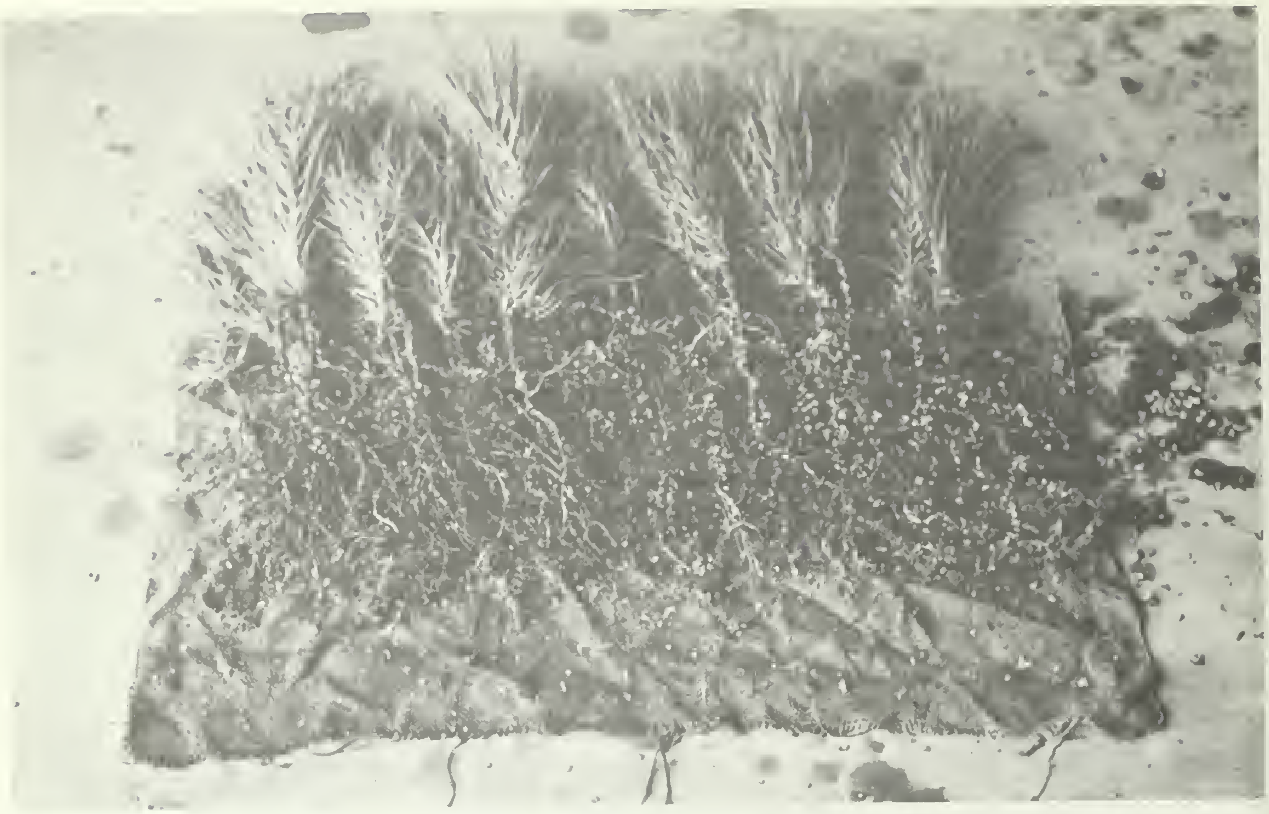

Figure 7.--Step 2: After dipping, an appropriate number of trees are placed on a 20- by 30-inch piece of wet burlap so their root collars are even with the long edge of the burlap and the roots are parallel to its short axis.

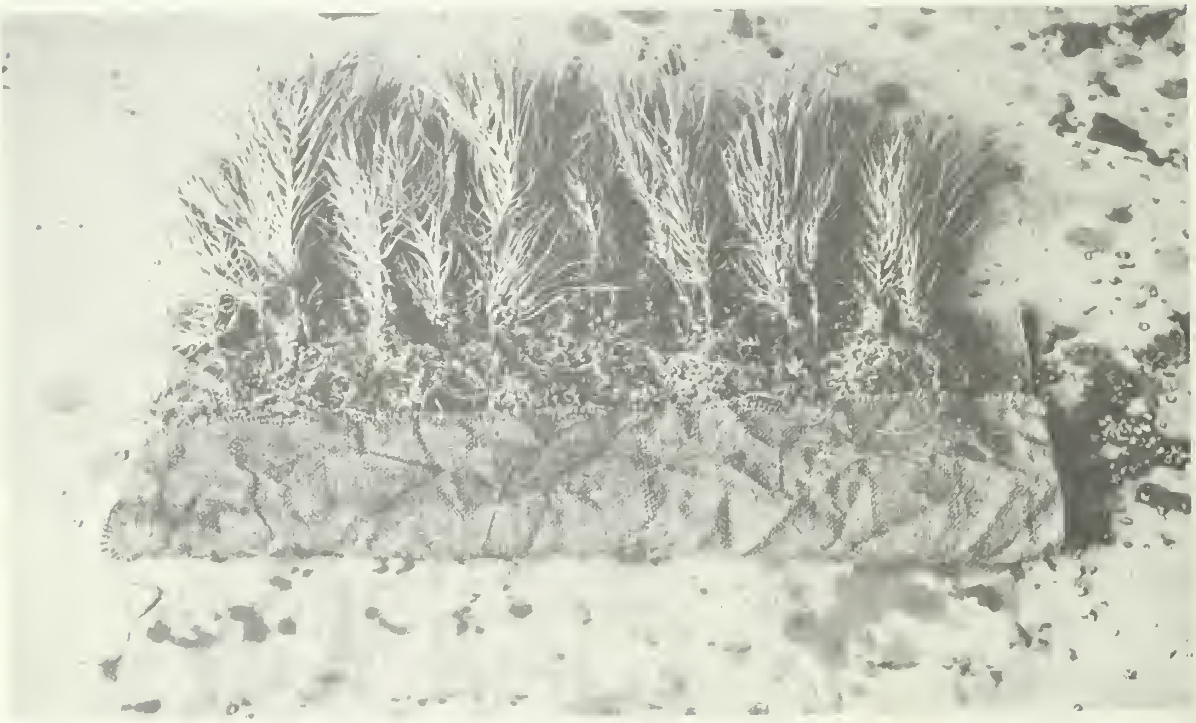

Figure 8.--Step 3: The burlap is then folded to cover the roots, taking care not to bend the roots into the fold.

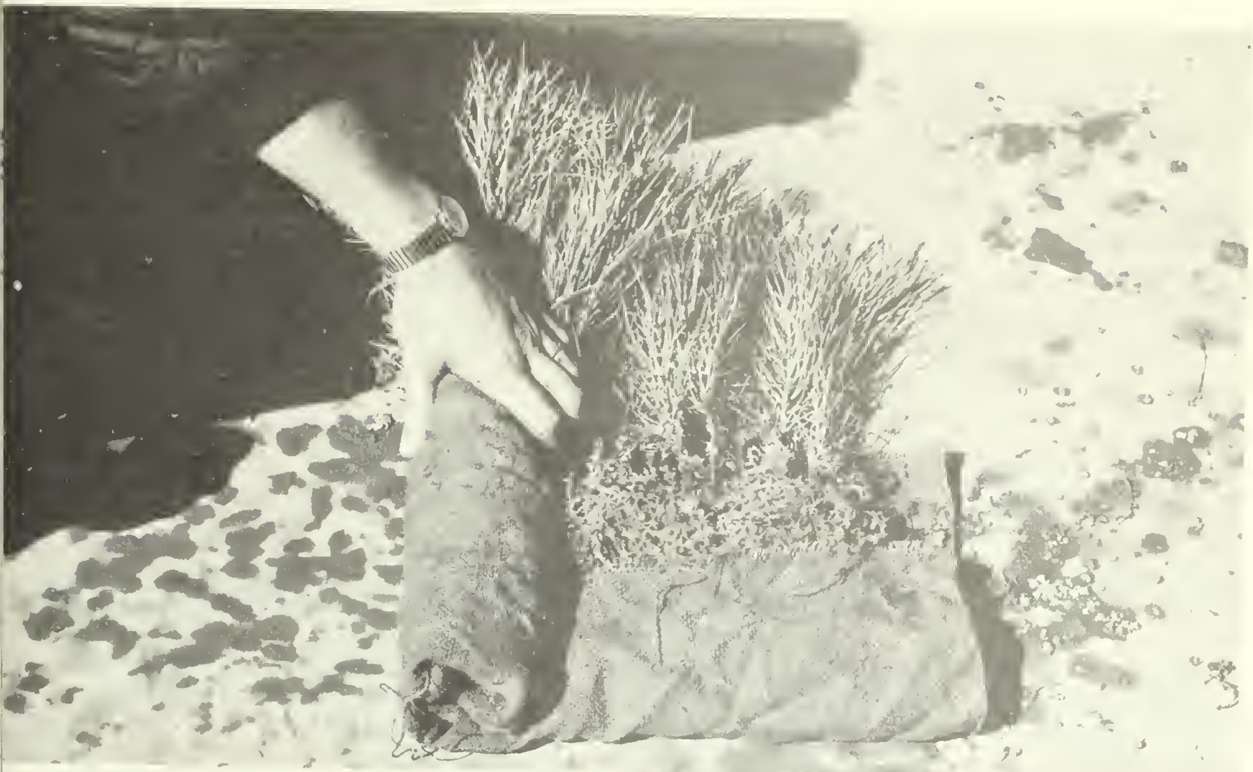

Figure 9.--Step 4: Burlap and trees are then rolled firmly from one end to the other.

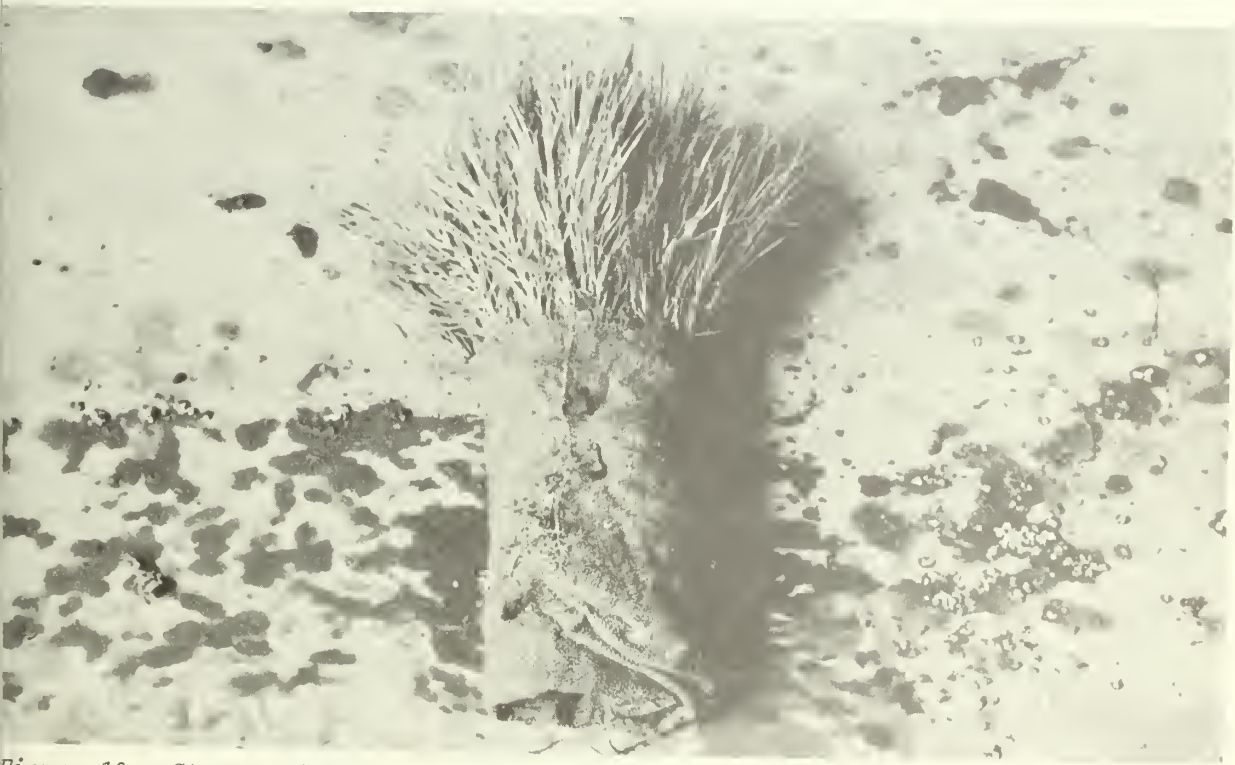

Figure 10.--Step 5: The outer end of the burlap is pinned in place with a 2-1/2-inch nail or other device.

SUMMARY

Properly constructed snow caches provide a good temperature and humidity regimen for storage of nursery stock.

The cache site should be convenient for the transportation to be used, should have adequate snow available when the trees arrive, and should be located where the snow will not melt too soon, making it necessary to disturb the trees again before planting.

Correct design of each storage compartment, or cell, assures the exclusion of harmful micro-organisms in the soil, and maintains the low temperatures needed to retard life processes of the trees and the development of any harmful organisms that might be present in the tree packages.

Construction in early spring favors accumulation of a large volume of snow of relatively low moisture content sufficient to promptly reduce and maintain temperatures just above freezing for an extended period.

Appropriate insulation will assure retention of an adequate snow mass through midsummer in most areas.

Correct handling and acclimatization of the trees to the atmospheric and soil conditions prevailing on the planting site minimize stress and increase survival and first-year growth of newly planted trees.

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FIRE ECOLOGY ??? QUESTIONS SURVEY

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ACKNOWLEDGMENT

It is a pleasure to express our gratitude to the land managers and scientists who gave their time, their thoughts, and their fine cooperation to this survey.

USDA Forest Service
General Technical Report INT-18
January 1975

FIRE ECOLOGY QUESTIONS SURVEY:

CANDID EXPRESSIONS OF RESEARCH NEEDS BY LAND MANAGERS AND SCIENTISTS IN WESTERN NORTH AMERICA

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This report is contribution No. 127, Ecosystem Analysis Studies, Coniferous Forest Biome. This research was sponsored through National Science Foundation Grant No. GB-20963, and under a cooperative agreement between the Intermountain Forest and Range Experiment Station, USDA Forest Service, and the University of Montana, Supplement No. 32 to 12-11-204-1.

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CONTENTS

Page

INTRODUCTION. 1

THE QUESTIONS SURVEY 2

HOW TO USE THIS REPORT 5

- Geographic Searching 6
- Topical Searching 6

COMMENTS. 7

QUESTION SETS 9

VOCABULARY 112

INDEX. 113

ABSTRACT

Contains 910 sets of forest fire ecology questions mailed to the authors by 302 land managers and scientists throughout the western United States and western Canada. Questions were submitted in response to a survey of important research needs for understanding the effects of fire and fire exclusion in western coniferous forest ecosystems. The questions cover the entire spectrum of environmental parameters affecting and affected by fire, and present, collectively, a compendium of candidly expressed research needs. A geographical source code and a topical keyword index permit selective searching of the question sets.

OXFORD: 181.43: 436: 435: 432.3: 434
KEYWORDS: fire ecology; fire effects; fire exclusion; fire research planning.

INTRODUCTION

Fire interacts with all environmental parameters in coniferous forest ecosystems. It exerts direct control on succession, setting it back to earlier stages, perpetuating subcycles, or in some cases setting it ahead. Fire is thus related to forest community structure and composition. It is also related to the rate at which trees grow, their condition, vigor, and resistance to insects and disease, their reproduction cycles and success, and their distribution. Energy, moisture, and nutrient systems are also related to fire, as are micro-organisms, soil-building factors, wildlife population dynamics, and hydrologic functions.

Recognizing the pervasive influence of fire, and citing the need for fuller understanding of fire's role in coniferous forests, the Directorate of the US/IBP Coniferous Forest Biome established the Fire Ecology Project in 1973 at the University of Montana, in Missoula.

The project, a cooperative effort among the Coniferous Forest Biome, the University of Montana, and the Intermountain Forest and Range Experiment Station, has as its objective the production of a problem analysis on the natural role of fire and its effects in western North American coniferous forests. The problem analysis will provide the basis for constructing systems-oriented computer simulation models directed toward solving the problems delineated. This report describes the first stage of our problem analysis development, a questions survey conducted by mail.

THE QUESTIONS SURVEY

Ecological systems modeling should be motivated by a set of explicit questions about the system.[1] Because it is vital to identify the most important questions to use limited research resources most efficiently, we decided to ask land managers and environmental scientists what they thought were the most pressing needs for understanding fire's role and its effects. In July 1973, we initiated a survey of 805 land managers and scientists throughout the western United States and western Canada. After selecting prospective respondents, we simply sent them letters of explanation and asked them to return written questions about fire and fire effects. We received almost 2,000 questions from the 411 respondents to the survey. The 910 question sets from 302 respondents listed here were compiled by combining closely related responses, and eliminating duplicates and a few irrelevant responses. The respondents were divided about equally between land managers and scientists.

Our procedure for selecting prospective respondents was designed to elicit opinions from the broadest possible spectra of land managers and environmental scientists with respect to geographic location, interest, and agency or institutional affiliation. It was not our intent to determine *the* most important fire ecology question. To the contrary, our purpose was to gain the broadest possible base of important questions. In general, we selected potential management respondents from private forest industry firms and public land management agencies. Potential scientist respondents were from academic institutions and Federal Government research laboratories.

For most land management employment categories, we arbitrarily selected 2 to 14 land managers per State or Province. For example, we decided to contact six State fish and game managers per State. The widest possible geographic distribution among six of the agency's field locations in each State was then sought, and the supervisory manager was selected in each of the locations. With few exceptions, the 448 land managers selected for the survey were unknown to the authors. The only employment category in which truly random selection of managers could be used and still insure wide geographic coverage was the U.S. Forest Service. With this agency, because of the large number of managers to choose from, two district forest rangers were selected at random from each of 93 National Forests. Table 1 shows the distribution of all prospective manager respondents by employment category, and by State or Province.

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[1] D. W. Goodall. Integration of shrub research effort, p. 435-439 in Wildland shrubs-their biology and utilization. USDA For. Serv., Gen. Tech. Rep. INT-1. 1972.

Table 1.--*Numbers of prospective respondents among land managers in 13 western States, 2 Canadian Provinces, and 1 Canadian Territory, by employment category and location*

State	State Forest Land Managers	Forest Service District Rangers	Private industry Forest Managers	Fish and Wildlife Service Refuge Managers	State Fish & Game Managers	BLM District Managers	BIA Area Foresters	Total
UNITED STATES								
Alaska	2	4	3	1	6	2	0	18
Arizona	2	15	3	0	6	1	2	29
California	3	30	5	3	6	2	4	53
Colorado	0	20	2	2	8	2	1	35
Idaho	2	23	5	3	6	2	0	41
Montana	2	19	6	2	6	2	4	41
New Mexico	3	15	4	1	6	2	2	33
Nevada	0	3	0	1	5	2	0	11
Oregon	3	19	5	2	6	3	1	39
South Dakota	2	3	1	0	3	0	0	9
Utah	0	12	0	1	6	3	0	22
Washington	3	14	5	5	6	1	3	37
Wyoming	2	9	0	1	6	2	0	20
	24	186	39	22	76	24	17	388

Province or Territory	Provincial Fish and Wildlife Managers	Private industry	Provincial Territorial Foresters	Total
CANADA				
Alberta	11	3	14	28
British Columbia	14	6	11	31
Yukon Territory	0	0	1	1
	25	9	26	60

Because scientists are typically grouped in laboratories and not widely distributed across any given geographic area, the emphasis of our scientist selection criteria was on research subject diversity. We wanted fire ecology questions from the most diverse environmental science audience possible.

We included scientists from widely separated government and academic research facilities throughout the study area (giving fairly wide geographic distribution), and purposely selected scientists whose research specialties and interests, collectively, covered the full range of environmental parameters affected by fire. Many of the scientists were known to us through their publications or previous correspondence. The distribution of scientists by State or Province and by employment category is shown in table 2. The few scientists located well outside the study area are individuals known by reputation to have fire research interests and experience with western coniferous forests.

Table 2.--*Numbers of prospective respondents among scientists in 17 States and 6 Canadian Provinces, by employment category and location*

State	Academic research	Forest Service research	Fish and Wildlife Service research	National Park Service research	Miscellaneous research	Total
UNITED STATES						
Alaska	3	9	2	0	0	14
Arizona	9	13	4	1	3	30
California	8	7	8	5	0	28
Colorado	13	6	15	1	0	35
Hawaii	1	0	0	0	0	1
Idaho	6	8	7	0	0	21
Michigan	2	0	0	0	0	2
Montana	25	23	6	1	0	55
New Mexico	1	1	2	0	0	4
Nevada	3	1	0	0	0	4
Oregon	10	9	10	0	0	29
South Dakota	1	3	0	0	0	4
Texas	1	0	0	0	0	1
Utah	6	9	11	0	0	26
Washington	16	4	8	1	0	29
Wyoming	0	1	2	4	0	7
Wash., D.C.	0	1	0	0	0	1
	105	95	75	13	3	291

Province	Academic research	Forestry Service research	Wildlife Service research	Total
CANADA				
Alberta	10	9	16	35
British Columbia	12	10	2	24
New Brunswick	1	0	0	1
Ontario	0	3	1	4
Quebec	1	0	0	1
Saskatchewan	1	0	0	1
	25	22	19	66

Following final selection of the 805 prospective respondents, each was assigned a response code number, and was thereafter known to us only by that number and by State/Province and vocation (scientist or land manager) code. Only the project secretary knew both an individual's name and code number. Thus, each respondent and his agency or employer were assured of anonymity. None of the question sets in this report are attributable to specific individuals or agencies.

Our letters to prospective respondents asked that they submit questions dealing only with the biological-physical role and effects of fire and fire exclusion, but some responses dealt with other aspects of fire management. These responses, and some generated by the authors, are included in this preponderantly ecologic effects report. The question sets have been subjected to minimal editing to preserve the general style, flavor, and candidness of the original responses.

HOW TO USE THIS REPORT

The question sets are identified and grouped only by State or Province, and are numbered consecutively from 1 to 910. The example below illustrates the format:

> 172. 02 130. WHAT ARE THE DIFFERENCES IN LITTER AND ACCUMULATION RATES (BY KIND OF LITTER MATERIAL) BETWEEN BURNED-OVER SITES AND AREAS FROM WHICH FIRE WAS EXCLUDED? WHAT SPECIFIC DECOMPOSER ORGANISMS ARE INVOLVED? HOW DO THE DIFFERENCES IN RATES CHANGE WITH HABITAT TYPE, SPECIES COMPOSITION, STAND AGE, DENSITY, ETC.? HOW DOES FERTILIZATION (ESPECIALLY WITH N AND Ca) AFFECT LITTER ACCUMULATION RATES (BY KIND OF LITTER MATERIAL) BETWEEN BURNED-OVER SITES AND AREAS FROM WHICH FIRE WAS EXCLUDED? WHAT SPECIFIC DECOMPOSER ORGANISMS ARE INVOLVED? HOW DO THE DIFFERENCES IN RATES CHANGE WITH HABITAT TYPE, SPECIES COMPOSITION, STAND AGE, DENSITY, ETC.? HOW DOES FERTILIZATION (ESPECIALLY WITH N AND Ca) AFFECT LITTER ACCUMULATION (NET) UNDER UNDISTURBED STANDS? MANIPULATION COMPARISON, FIRE EXCLUSION, LITTER DECOMPOSITION, FUEL-BIOMASS ACCUMULATION, MICROORGANISMS, SPECIES DIVERSITY, DENSITY, AGE, NUTRIENTS.

The number in the left margin is the set number (1 to 910). The middle two-digit number is the State/Province code (see tabulation). The three-digit respondent code, located to the right of the State/Province code, is the same for all question sets submitted by an individual respondent. Thus, the three sets in this report bearing respondent code 130 were submitted by one respondent in Idaho. The respondent codes are given here only to show the continuity that sometimes exists between two or more question sets from a given respondent. The sets having State/Province code "00" and respondent code "000" originated either in the project office or in locations outside the western States and Provinces shown in the tabulations. In the example, the 10 terms following the last question mark are descriptors, or keywords, that characterize the question set and correspond to the keywords in the Index and Vocabulary. Appropriate keywords are appended to all of the question sets in the report.

Geographic Searching

To find the group of question sets from a particular State or Province, simply find its two-digit code below, then turn to the appropriate section of the report. All of the question sets are listed in increasing order of the State/Province code numbers.

Location	*Code*	*Location*	*Code*
Project Office	00	Nevada	08
Washington	01	Utah	09
Idaho	02	Colorado	10
Montana	03	Arizona	11
South Dakota	04	New Mexico	12
Oregon	05	Alaska	13
Wyoming	06	British Columbia	14
California	07	Alberta	15
		Ontario	17

Topical Searching

The question-set list is followed by a keyword vocabulary list and a keyword index. To use the report for topical searching, one should look in the vocabulary section for the desired keywords and then consult the Index for all question-set numbers listed under the selected keywords, and flip through the body of the report until the desired question sets are located. The keywords "experiment oriented question" indicate the authors' belief that the question is especially oriented to field or laboratory experiments.

COMMENTS

The primary purpose of the Questions Survey was to provide a broad input base to our problem analysis. In the second stage of the problem analysis, to be reported elsewhere, we're using the questions in another way. The responses are synthesized into fire ecology problem areas and ranked as to their research importance by two panels of expert land managers and scientists by the Delphi method.[2] Perhaps the greatest value of the responses is through sharing them with other land managers, administrators, environmental scientists, students, and the general public. We believe the question sets collectively express the most important needs for understanding the ecologic effects of fire.

The reader who is familiar with the literature will recognize that answers to some of the questions do not really require more field research because a considerable body of literature already exists. Here we have a case of poor information diffusion from research to on-the-ground ecosystem managers. In other cases, the questions require information discovery since very little literature exists. Here, discovery may require fieldwork with concurrent simulation modeling to guide and integrate the field research inquiries.

The practicing land manager may note striking similarities among question sets from different geographical areas, suggesting that only a handful of basic principles--modified by climate, species, and geographic factors--are at work. The administrator may wish to compare specific problems among land managers throughout his area of interest. The senior or graduate student in resource management or environmental research programs will find among these question sets many real-world problems worthy of earnest effort.

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[2] J. Pill. The Delphi method: substance, context, a critique and an annotated bibliography. J. Econ. and Soc. Plann. Sci., 5:5771. 1971.

Many of the question sets are oriented toward fire ecology as a basic ecological science, while others are oriented toward using fire as a management tool to control some specific biological organism or process. A large number of the respondents identified information needs from an organism orientation; few focused directly on ecological principles. Still fewer focused directly on natural fire in a community-ecosystem behavior context. This is particularly evident in the question sets on animal organisms, compared to the virtual absence of inquiries on fire effects in food web structure and dynamics in coniferous forest seres.

We suggest that environmental scientists can benefit by studying these research needs with the "mirror" concept in mind. With this concept, each scientist should read the expressed needs for information, understanding, and prediction ability, from the perspective of his own particular specialty. He should then be able to "read between the lines" to see what the solution of any given need would require from his environmental specialty. Using the "mirror" concept and "questioning" should be an ongoing, daily activity for every scientist so that his investigations are problem-centered and don't become means-centered.[3] Even though seeking the best questions to ask is an infinite activity, a systematic logging and analysis of research needs must begin somewhere. This list is a beginning--a "snapshot in time," possessing questions of variable quality. We hope it will be both useful and stimulating to those doing research in the broad spectrum of fields relating to fire ecology.

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[3] A. H. Maslow. Motivation and personality. Chap. 2, *in*: Problem centering vs. means centering in science. Harper and Row, New York. 1970.

QUESTION SETS

1. 00 000 CONSIDERING PIONEER PLANT SPECIES, WHOSE SEED DISPERSAL RANGE IS LIMITED BY WIND, CAN CHANGES IN THE AREAL EXTENT OF CROWN BURNS AFFECT THE RATE OF SECONDARY SUCCESSION THROUGHOUT THE BURNED AREA? SEED,DISPERSION,SUCCESSION,MOSAIC,CROWN BURN

2. 00 000 DO DIFFERENT CONCENTRATIONS OF WOOD SMOKE FROM VARIOUS GRASS, SHRUB, TREE, OR DUFF TYPES HAVE AN ALTERING EFFECT ON THE LIGHT SATURATION LEVEL FOR PHOTOSYNTHESIS IN DIFFERENT TREE SPECIES? SMOKE EFFECTS,ORGAN,PRODUCTIVITY,EXPERIMENT ORIENTED QUESTION

3. 00 000 DO VARIOUS CONSTITUENTS OF WOOD SMOKE EVER INTERFERE WITH THE PHYSIOLOGIC RESPONSE OF GUARD CELLS CONTROLLING STOMATE BEHAVIOR ON ANY TREE SPECIES IN WESTERN CONIFEROUS FORESTS? SMOKE EFFECTS,ORGAN,PRODUCTIVITY,EXPERIMENT ORIENTED QUESTION

4. 00 000 DOES THE DEGREE OF IONIZATION (+ OR -) OF GROUND-LEVEL AIR HAVE ANY EFFECT ON THE ACTIVITY PATTERNS OF SPRUCE BUDWORM, DOUGLAS-FIR TUSSOCK MOTH, OR PINE BARK BEETLE?--ASIDE FROM REVERSED ELECTRICAL FIELDS WITH THE PASSAGE OF A THUNDERSTORM, DOES WOOD SMOKE CONCENTRATION INFLUENCE THE DEGREE OF IONIZATION OF THE GROUND-LEVEL AIR? SMOKE EFFECTS,INSECT,EXPERIMENT ORIENTED QUESTION

5. 00 000 DOES WOOD SMOKE CONCENTRATION AND DEPOSITION ON THE NESTS OF ANY SPECIES OF BIRDS HAVE AN INFLUENCE ON THAT BIRD SPECIES' SUBSEQUENT BEHAVIOR WITH REGARD TO THE NEST? (ASSUME NO FIRE AROUND THE NEST AREA,---ONLY ADVECTED WOOD SMOKE.) SMOKE EFFECTS,BIRD,ORGANISM,EXPERIMENT ORIENTED QUESTION

6. 00 000 HOW DO YOU MANAGE FIRE TO AFFECT BEAR FOOD RESOURCES? WOULD THIS CHANGE THE BEAR POPULATION ANYWAY? GAME ANIMAL,HERBIVORY,POPULATION

7. 00 000 HOW DO YOU MANAGE TO MAXIMIZE AESTHETIC DIVERSITY OF FOREST-FLOOR HERBS? (AESTHETIC DIVERSITY DEFINED AS SCATTER IN A SPACE WITH THREE DIMENSIONS REPRESENTING FLOWER COLOR SPECTRUM, FLOWER HEIGHT, AND FLOWERING DATE.) (I SUGGEST YOU TAKE THE "SMALL WATERSHED", <1000 ACRES, AS THE SPATIAL UNIT.) AESTHETICS

8. 00 000 HOW MUCH RAIN IS NECESSARY TO RINSE ALL CHEMICAL FIRE RETARDANT OUT OF THE CROWN OF CONIFERS IN VARIOUS SIZE CLASSES? CHEMICAL RETARDANT EFFECTS,HYDROLOGY,CROWN,ORGAN,EXPERIMENT ORIENTED QUESTION

9. 00 000 IS IT POSSIBLE THAT WITH NATURAL FIRE FREQUENCY THE FUEL LOADS AWAY FROM THE STREAM WERE KEPT RELATIVELY LOW, SUCH THAT INTENSITIES OF FIRES WERE NOT USUALLY

GREAT ENOUGH TO IGNITE THE STREAM BANK VEGETATION? --BUT WITH FIRE EXCLUSION, INCREASED FUEL LOADS WILL LEAD TO GREATER INTENSITIES OF FIRE, WHENEVER IT DOES OCCUR, SUCH THAT THE INTENSITY WILL EXCEED A THRESHOLD VALUE NECESSARY TO IGNITE RIPARIAN VEGETATION AND THEREBY REMOVE THE STREAM COVER? FIRE FREQUENCY,FIRE BEHAVIOR,STREAM,FUEL/BIOMASS ACCUMULATION,POPULATION

10. 00 000 IT IS OFTEN HELD THAT FIRE INCREASES THE CONCENTRATION OF AVAILABLE NUTRIENTS IN THE SURFACE SOIL. IS THIS EFFECT MORE MARKED IN HARDWOODS THAN SOFTWOODS, AND IS IT ALSO MORE PRONOUNCED ON HIGH BASE STATUS SOILS THAN ON LOW BASE STATUS SOILS? NUTRIENTS,SOIL

11. 00 000 UNDER WHAT CIRCUMSTANCES WOULD A SINGLE FIRE, OR OTHER PERTURBATION SUCH AS NUTRIENT ENRICHMENT, CHANGE THE CLIMAX ON A PARTICULAR SITE? (YOU MIGHT CONSIDER THIS IN TWO PARTS: FIRST, WHAT SITE VARIABLE MUST YOU KNOW TO PREDICT CLIMAX IN THE ABSENCE OF FIRE; SECOND, WHICH OF THESE COULD BE PERMANENTLY CHANGED BY A SINGLE PERTURBATION OF THE RIGHT KIND?) ECOSYSTEM,SUCCESSION

12. 00 000 UNDER WHAT CONDITIONS COULD FIRE SUPPRESSION ON FORESTED SLOPES ACCELERATE AQUATIC SUCCESSION IN ADJACENT LOWLAND WATER BODIES, AND SUBSEQUENTLY ELIMINATE WATERFOWL HABITATS? FIRE EXCLUSION,TOPOGRAPHY,AQUATIC,SUCCESSION,BIRD,ECOSYSTEM

13. 00 000 UNDER WHAT CONDITIONS MIGHT THE BASES OF SNAGS ACT AS REFUGIA FOR THE PIONEER FORBS, BECAUSE OF INCREASED SOIL MOISTURE FROM SNAG INTERCEPTION AND STEM FLOW? SNAG,ECOSYSTEM,SOIL-WATER RELATIONS,MICROCLIMATE,CROWN BURN

14. 00 000 WHAT COULD BE THE EFFECT OF CHANGES IN THE QUANTITY OF CHARCOAL ON THE SOIL SURFACE, AS SEEN IN THE GERMINATION AND SEEDLING SURVIVAL OF DOUGLAS-FIR? CHARCOAL,MICROCLIMATE,ORGANISM,REPRODUCTION

15. 00 000 WHAT COULD BE THE EFFECT OF CHANGING THE PROPORTION AND POSITION OF CROWN BURNS IN A WATERSHED, AS SEEN IN THE DEPTH OF THE NOCTURNAL INVERSIONS IN THE TRIBUTARIES AND THE VELOCITY OF THE NOCTURNAL CANYON WIND OUT OF THE WATERSHED? MOSAIC,MORTALITY,MICROCLIMATE,CROWN BURN

16. 00 000 WHAT EVIDENCE IS THERE TO INDICATE THAT IRON MOBILIZATION HAS BEEN INCREASED AS THE RESULT OF INTENSE FOREST FIRES IN HUMID FOREST AREAS? SOIL,ELEMENTS,FIRE BEHAVIOR

17. 00 000 WHAT IS THE EFFECT OF COVERING VARIOUS TREE SPECIES WITH FIRE RETARDANT (AMMONIUM PHOSPHATE?) AS SEEN IN THE PHOTOSYNTHESIS RATE OF THE TREE'S CROWN AS A UNIT? CHEMICAL RETARDANT EFFECTS, CROWN,PRODUCTIVITY,ORGAN,EXPERIMENT ORIENTED QUESTION

18. 00 000 WHAT IS THE EFFECT OF RUNOFF, HEAVY WITH NUTRIENTS, FROM A BURN INTO A HIGH MOUNTAIN LAKE, AS OBSERVED IN THE FISH POPULATION AND OTHER AQUATIC LIFE IN THE LAKE? NUTRIENTS,LAKE,FISH,POPULATION

19. 00 000 WHAT MIGHT BE THE EFFECT OF A CHANGE IN SNAG DENSITY AS SEEN IN THE MAXIMUM GROUND-SURFACE INTERFACE TEMPERATURE IN POST-CROWN FIRE ENVIRONMENT? SNAG,MICROCLIMATE,CROWN BURN

20. 00 000 WHAT MIGHT BE THE EFFECT OF CHANGES IN LITTER ACCUMULATION AS SEEN IN RODENT SEED CACHING PATTERNS AND THE REGENERATION OF SHRUBS? FUEL/BIOMASS ACCUMULATION,FIRE EXCLUSION,LITTER,SEED,SMALL MAMMAL,POPULATION,SHRUBLAND,REPRODUCTION

21. 00 000 WHAT MIGHT BE THE EFFECT OF CHANGES IN THE INTENSITY OF A FIRE, AS OBSERVED IN THE DENSITY OF VIABLE SEEDS IN THE SOIL AND THE DENSITY OF SOIL ARTHROPODS, ESPECIALLY CARABIDS? FIRE BEHAVIOR,SEED,ARTHROPODS,POPULATION,SOIL

22. 00 000 WHAT MIGHT BE THE EFFECT OF CHANGING FIRE FREQUENCY AND INTENSITY, AS SEEN IN THE FUEL LOAD ON A SITE? UNDER WHAT CONDITIONS CAN FIRES CAUSE AN INCREASE IN FUEL LOADS? FUEL/BIOMASS ACCUMULATION,REPRODUCTION,MORTALITY,DECOMPOSITION,SUCCESSION,FIRE FREQUENCY,FIRE BEHAVIOR

23. 00 000 WHAT MIGHT BE THE EFFECT OF FIRE EXCLUSION ON INSECT POPULATION DYNAMICS, WHOSE REPRODUCTIVE ACTIVITIES ARE TRIGGERED BY FIRE EVENTS? FIRE EXCLUSION, INSECT,POPULATION,REPRODUCTION

24. 00 000 WHAT MIGHT BE THE EFFECT OF INCREASING THE LITTER AND DUFF LAYER THICKNESS BENEATH A PONDEROSA PINE CANOPY, AS SEEN IN THE MOISTURE REGIMEN IN THE UNDERLYING MINERAL SOIL? IS IT POSSIBLE FOR THE LITTER LAYER TO SHORT-CIRCUIT THE FLOW OF MOISTURE TO TREE ROOTS? HOW DRY MUST THE ROOTING ZONE REMAIN BEFORE NO NET ANNUAL GROWTH IN THE TREE SYSTEM OCCURS? DOES TREE TISSUE WATER STRESS INFLUENCE FLAMMABILITY? FIRE EXCLUSION,LITTER,FUEL/BIOMASS ACCUMULATION,SOIL-WATER RELATIONS,ROOTS,POPULATION,PRODUCTIVITY

25. 00 000 WHAT MIGHT BE THE EFFECT OF SNAG DENSITY ON THE MELTING RATE OF THE SNOW PACK IN THE SPRING? CROWN BURN,SNAG,DENSITY,HYDROLOGY,SNOW

26. 00 000 WHAT MIGHT BE THE EFFECT OF VARIOUS DEGREES OF DUFF REMOVAL AND MINERALIZATION, AS SEEN IN THE EMERGENCE OF VARIOUS PLANT SPECIES FROM THE SOIL? LITTER,REPRODUCTION,VEGETATION,POPULATION

27. 00 000 WHAT PROCEDURES ARE RECOMMENDED FOR POROSITY DETERMINATIONS OF ASHED ORGANIC SURFACES? EXPERIMENT ORIENTED QUESTION,ASH,SOIL STRUCTURE

28. 00 018 WHAT WOULD HAPPEN, IF IN FOREST TYPES OTHER THAN PONDEROSA PINE, CONTROLLED BURNING (CROWN FIRE) PRECEDED HARVEST? THIS WOULD BE DONE TO ELIMINATE ALL OF THE PRESENT POST-LOGGING TREATMENTS, PERHAPS. ALTHOUGH SOME TIMBER MIGHT BE LOST, SOME REDUCED IN QUALITY, WOULD TOTAL AND LONG-RANGE COSTS AND BENEFITS BE MORE OR LESS? MANIPULATION COMPARISON

29. 00 051 CAN WE EVENTUALLY ACCOMPLISH MOST OF OUR OBJECTIVES FROM BURNING IN CONFEROUS FORESTS WITH LOW INTENSITY FIRES? ARE SOME HIGH INTENSITY FIRES NECESSARY? MAYBE THE BEST FIRE IS ONE WITH A WIDE VARIETY OF INTENSITIES. FIRE INTENSITY,MANIPULATION COMPARISON,EXPERIMENT ORIENTED QUESTION

30. 00 051 FOR MAXIMUM ESTABLISHMENT AND SURVIVAL OF NEW TREES FOLLOWING A BURN, HOW WISE IS IT TO RESEED BURNS WITH GRASS? PRESENTLY, THE MORTALITY IS VERY HIGH AND I SUSPECT THAT COMPETITION FROM GRASS HAS A LOT TO DO WITH IT. COMMUNITY,COMPETITION,REPRODUCTION

31. 00 051 HOW CAN DOUGLAS-FIR COMMUNITIES BE BURNED AND STILL RESEED THEMSELVES NATURALLY? REPRODUCTION,SEED

32. 00 051 HOW DO MICROENVIRONMENT CHANGES, CAUSED BY FIRE, ENHANCE FIRE-LOVING SPECIES SUCH AS ASPEN AND MANY SHRUBS? EXPERIMENT ORIENTED QUESTION

33. 00 051 HOW ESSENTIAL IS FIRE IN CONTROLLING THE BOUNDARY BETWEEN FORESTS AND GRASSLANDS? SUCCESSION,ECOTONE,MOSAIC,GRASSLAND

34. 00 051 WHAT IS THE ROLE OF FIRE IN THE VARIOUS LODGEPOLE PINE COMMUNITIES? CAN FIRE BE USED TO CHANGE THE COMPOSITION OF THESE COMMUNITIES TO ENHANCE WILDLIFE FORAGE? COMMUNITY,SHRUB UNDERSTORY,HERBAGE UNDERSTORY,PRODUCTIVITY

35. 00 053 CAN THE FUNGUS PORIA WEIRII, WHICH CAUSES ROOT ROT IN DOUGLAS-FIR AND WHICH EXISTS IN DEAD ROOT MATERIAL IN THE SOIL AND ATTACKS ROOTS OF LIVING TREES, BE DESTROYED BY USE OF FIRE? FUNGUS,ROOTS,SOIL,ORGANISM

36. 00 053 DOES FIRE SUPPRESSION INCREASE OR DECREASE LEVELS OF DISEASE AND INSECT PESTS IN FOREST ECOYSYSTEMS? FIRE EXCLUSION,DISEASE,INSECT

37. 00 053 HOW ARE LEVELS AND TYPES OF SOIL MICROORGANISMS AFFECTED BY FIRE? DOES OCCASIONAL LOW INTENSITY BURNING INCREASE SOIL MICROBIAL ACTIVITY AND ALLOW FOR RETENTION OF NUTRIENTS IN THE ECOSYSTEM, OR ARE THE RELEASED NUTRIENTS LOST TO RUN OFF AND DEEP PERCOLATION? MICROORGANISM,FIRE INTENSITY,NUTRIENTS,HYDROLOGY,COMMUNITY

38. 00 053 HOW MUCH DO FOREST FIRES CONTRIBUTE TO GENERAL LEVELS OF AIR POLLUTION IN COMPARISON TO INDUSTRIAL SOURCES OF AIR POLLUTIONS? AIR POLLUTION

39. 00 053 WHAT EFFECT DOES FIRE AT VARYING INTENSITIES HAVE ON LEVELS OF FOLIAGE DISEASES, ROOT DISEASES AND INSECT PEST POPULATIONS? FIRE INTENSITY,DISEASE,CROWN,ROOTS,INSECT,POPULATION

40. 00 054 DOES, OR HAS, FIRE MAINTAINED THE DISPUTED "CLIMAX" POSITION OF POPULUS TREMULOIDES IN AREAS OF THE GREAT BASIN? SUCCESSION, DECIDUOUS FOREST

41. 00 054 HOW DOES FUEL FLAMMABILITY CHANGE ALONG LATITUDINAL OR ECOLOGICAL GRADIENTS WITHIN THE RANGE OF PINUS PONDEROSA, P. MONTICOLA, LARIX OCCIDENTALIS, PSEUDOTSUGA MENZIESII (AND OTHER SPECIES)? FLAMMABILITY,CONTINUUM

42. 00 054 IS THE BARK THICKNESS GREATER IN THE PROGENY OF TREES THAT SURVIVED IN PERIODS WHEN FIRE WAS FREQUENT (FOR EXAMPLE, P. PONDEROSA TREES NOW OVER 300 YRS. OLD) THAN IN PROGENIES OF TREES NOW REPRODUCTIVELY MATURE (50-60 YRS.) THAT HAVE NOT BEEN SUBJECTED (I.E., UNSELECTED) TO PERIODIC FIRES? IN OTHER WORDS HAS THERE BEEN A CHANGE IN THE GENETIC STRUCTURE OF THE POPULATIONS IN THIS CHARACTERISTIC IN TWO GENERATIONS? HEAT EFFECTS,FIRE FREQUENCY,STEM,GENETIC RESPONSE,POPULATION

43. 00 054 NON-WETTABLE SOILS ARE KNOWN TO OCCUR WHERE NON-WETTABLE SUBSTANCES, DERIVED FROM PLANTS AND PLANT LITTER, ACCUMULATE IN THE SOIL: THEY ARE AFFECTED BY SOIL TEMPERATURES IN VARIOUS WAYS DURING FIRES. THE PLANTS ON SUCH SITES CONTAIN THESE CHEMICALS APPARENTLY BECAUSE THEY ARE OF SELECTIVE ADVANTAGE TO THESE PLANTS, AND FIRE MAY BE PART OF THIS SYSTEM. WHAT ARE THE PLANT-FIRE-SOIL RELATIONSHIPS THAT FAVOR THE PRODUCTION OF THESE COMPOUNDS? IN WHAT WAY IS NON-WETTABLE SOIL (INDIRECTLY FIRE INDUCED) OF SELECTIVE ADVANTAGE TO THE SHRUB SPECIES GROWING ON THESE SITES? SOIL-WATER RELATIONS,FIRE BEHAVIOR

44. 00 054 WHAT ARE THE RELATIVE FUEL FLAMABILITIES OF CONIFEROUS SPECIES IN WESTERN FORESTS AND HOW ARE THESE VALUES RELATED TO THEIR SUCCESSIONAL POSITION (EARLY-SUCCESSIONAL, MID-SUCCESSIONAL, LATE-SUCCESSIONAL)? FLAMMABILITY,SUCCESSION

45. 00 054 WHAT IS THE CORRELATION BETWEEN FLAMMABILITY AND THE FREQUENCY OF FIRES THROUGHOUT THE RANGE OF A GIVEN SPECIES? FLAMMABILITY,FIRE FREQUENCY

46. 00 218 WHAT IS THE PROBABILITY THAT DOUGLAS FIR ON "FIRE-MAINTAINED" SITES WILL REACH HARVESTABLE MATURITY, AND HOW DOES IT COMPARE TO PINE? FIRE EXCLUSION,ECOSYSTEM,SUCCESSION,PRODUCTIVITY

47. 00 560 HOW CAN WE PREDICT THE EFFECTS OF A HOT GROUND FIRE FOLLOWING A CROWN FIRE ON SOIL FERTILITY? WHAT DEGREE OF STERILITY WILL OCCUR, IF ANY? HEAT EFFECTS,FIRE EFFECTS,SOIL,NUTRIENTS,FIRE INTENSITY

48. 00 560 WHAT ARE THE ECONOMIC TRADE-OFF VALUES OF LEAVING NESTING TREES FOR VARIOUS WILDLIFE SPECIES IN TIMBER SALES, CONSIDERING SOME OF THESE NESTING TREES MAY BE DISEASED OR BE INFESTED WITH INSECTS? ECONOMIC EFFECTS,BIRD,SMALL MAMMAL,INSECT,HUMAN DISTURBANCE,DISEASE

49. 01 036 WHAT EFFECT DOES FIRE INTENSITY, SIZE AND FREQUENCY HAVE ON LAKES IN VARYING TROPHIC STATES (PRODUCTIVITY OF DIFFERENT LAKE COMMUNITIES OF FISH, PLANKTON AND BENTHOS) AND IN DIFFERENT WATERSHEDS (DIFFERENT WATER AND NUTRIENT BUDGETS)? FIRE INTENSITY,AREA SIZE,FIRE FREQUENCY,LAKE,PRODUCTIVITY,WATERSHED,HYDROLOGY,NUTRIENTS

50. 01 036 WHAT EFFECT DOES FIRE INTENSITY,SIZE, FREQUENCY AND CHANGE IN DETRITAL ACCUMULATION HAVE ON ORGANIC AND INORGANIC SUBSTRATE COMPOSITION AND MINERALIZATION IN BOTTOM SEDIMENTS OF LAKES? A) IF CHANGES OCCUR, WILL THE VARIATIONS BE RELATED TO PROPORTIONS AND DIFFERENCES IN AVAILABILITY OF CARBON AND NITROGEN IN VARIOUS ORGANIC SUBSTRATES? B) HOW DO CHANGES IN THE AVAILABILITY OF ORGANIC NITROGEN LIMIT THE UTILIZATION OF CARBON COMPOUNDS? FIRE INTENSITY,AREA SIZE,FIRE FREQUENCY,FUEL REDUCTION,LAKE,NUTRIENTS

51. 01 037 DO THE "ASHBED EFFECTS" OF BURNING, SO WELL KNOWN IN AUSTRALIA AND NEW ZELAND OCCUR IN WESTERN NORTH AMERICA? EXPERIMENT ORIENTED QUESTION

52. 01 037 DOES THE EXCLUSION OF FIRE RESULT IN TOXIC ACCUMULATIONS AND CONTRIBUTE TO MORTALITY OF, FOR EXAMPLE, REDWOODS? FIRE EXCLUSION,ALLELOPATHY,MORTALITY

53. 01 037 THE FIRST NEED IS TO DEFINE A MORE OR LESS STANDARD METHOD OF MEASURING FIRE INTENSITY, IN PARTICULAR, AND OTHER BEHAVIOR CHARACTERISTICS. EXPERIMENT ORIENTED QUESTION

54. 01 037 HOW DOES FIRE INFLUENCE THE MICROCLIMATE AND MORE SPECIFICALLY THE ENERGY BUDGET AND WATER BALANCE OF A SITE AND SO THE REGENERATING CROP? MICROCLIMATE

55. 01 037 UNDER WHAT CIRCUMSTANCES AND BURNING CONDITIONS IS SLASH BURNING AN ECOLOGICALLY AND ECONOMICALLY JUSTIFIABLE METHOD OF SITE PREPARATION - IN TERMS OF EROSION, SOIL NUTRIENT STATUS, SEEDLING DEVELOPMENT, PERCENT SPECIES DEVELOPMENT, CROP ECONOMICS? FUEL REDUCTION,SOIL EROSION,NUTRIENTS,REPRODUCTION,ECOSYSTEM

56. 01 038 DOES FIRE INDUCE FIXATION OF POTASSIUM? NUTRIENTS

57. 01 038 DOES FIRE INDUCE FORMATION OF CONCRETIONS ON NODULES? SOIL STRUCTURE

58. 01 038 DOES FIRE OXIDIZE AND DEHYDRATE AMORPHOUS SESQUIOXIDES? IF THIS IS THE CASE, THE SOIL WOULD PROBABLY ACQUIRE A BETTER STRUCTURE BUT DECREASE ITS CATION EXCHANGE CAPACITY. SOIL STRUCTURE,NUTRIENTS

59. 01 038 HAS FIRE ANY EFFECT ON NUTRIENTS RELEASE FROM THE COLLOIDAL FRACTION? NUTRIENTS

60. 01 038 THE PHENOMENON IS KNOWN TO OCCUR AS RESULT OF FIRE, BUT WHAT ARE THE CONDITIONS FOR INDUCING HYDROPHOBICITY IN THE SOIL? FIRE INTENSITY,SOIL-WATER RELATIONS

61. 01 038 WHAT IS THE EFFECT OF FIRE ON COLLAPSING OF EXPENDABLE MINERALS SUCH AS VERMICULITE OR MONTMORILLONITE? SOIL STRUCTURE

62. 01 040 IN SMALL MAMMALS, THE PETRUCEWICZ EFFECT SAYS THAT SEVERE ALTERATION OF THE ENVIRONMENT WILL CAUSE A RISE IN THE REPRODUCTIVE RATE THROUGH A WEAKENING OF SOCIAL CONTROLS. HOW IMPORTANT IS THIS EFFECT IN THE POPULATION DYNAMICS OF MAMMALS IN ENVIRONMENTS WHICH ARE BURNED OVER? SMALL MAMMAL,REPRODUCTION,POPULATION,ANIMAL BEHAVIOR

63. 01 040 WHEN A SPROUTING SHRUB IS BURNED, THERE ARE TWO EFFECTS: -- A MECHANICAL GIRDLING WHICH INDUCES SPROUTING, AND THE FERTILIZATION FROM THE ASH. HOW MUCH IS EACH OF THESE INVOLVED IN THE PRE-AND POST-BURN NUTRIENT QUALITY OF THE FORAGE? SHRUBLAND,ORGAN,NUTRIENTS,ASH

64. 01 042 WHAT KINDS OF FIRE PRODUCE HYDROPHOBICITY IN SOILS? HOW DOES TEMPERATURE RELATE TO THE DEPTH OF HYDROPHOBICITY? HOW DOES FIRE AFFECT SOIL STRUCTURE? CAN THESE RELATIONSHIPS BE QUANTIFIED? SOIL-WATER RELATIONS,FIRE INTENSITY,SOIL STRUCTURE

65. 01 043 HOW AND TO WHAT DEGREE ARE KEY PROCESSES OF NUTRIENT MOBILIZATION/IMMOBILIZATION AFFECTED BY FOREST FIRES OF DIFFERENT KINDS AND INTENSITY? (KEY PROCESSES BEING CHEMICAL SOLUTION AND FIXATION, BIOLOGICAL MINERALIZATION AND UPTAKE, AND TRANSFER MECHANISMS OF THE MAJOR NUTRIENTS (N,P,K,CA) WITHIN THE SOILS) HOW LONG DO THESE EFFECTS LAST AND WHAT ARE THE CONSEQUENCES FOR LONGTERM (SUCCESSIONAL, EROSIONAL) PROCESSES, OR HOW DO THE PARAMETERS FOR NUTRIENT BEHAVIOR MODELS VARY WITH ECOSYSTEM DEVELOPMENT? FIRE INTENSITY,NUTRIENTS,SUCCESSION,SOIL EROSION

66. 01 043 HOW AND TO WHAT DEGREE IS THE BUFFER CAPACITY IN THE FOREST SOIL FOR NUTRIENT CONSERVATION, POLLUTANT RETENTION, AND WATER STORAGE AFFECTED BY FIRES OF DIFFERENT KINDS AND INTENSITIES? FIRE INTENSITY,NUTRIENTS,SOIL-WATER RELATIONS

67. 01 046 THERE IS A NEED TO UNDERSTAND INTERRELATIONSHIPS BETWEEN FOREST FIRES AND INSECTS - PARTICULARLY BARK BEETLES. FOR EXAMPLE, LODGEPOLE PINE STANDS ARE PASSED ON TO FUTURE SUCCESSIONAL STAGES BY LIGHT/MEDIUM FIRES WITH THE AID OF THE MOUNTAIN PINE BEETLE. WHAT WOULD HAPPEN IF FIRE WERE EXCLUDED ENTIRELY? POSSIBLY, STAND DYNAMICS WOULD DEPEND ENTIRELY ON BARK BEETLES I.E., THERE WOULD BE TOTAL STAND DESTRUCTION WITHOUT THE AID OF FIRE TO REGENERATE THE STANDS. ON THE OTHER HAND, FIRE EXCLUSION IN PONDERSOA PINE STANDS WOULD YIELD DENSER STANDS, AND MORE LOST MATERIAL FOR DENDROCTONUS PONDEROSAE. HOWEVER, THERE IS THE POSSIBILITY THAT MORE STEMS/ACRE COULD BE CARRIED FORTH I.E., ADDITIONAL VIGOROUS, NON-SUSCEPTIBLE TREES WOULD BE MAINTAINED.
INSECT,SUCCESSION,FIRE INTENSITY,FIRE EXCLUSION,POPULATION,REPRODUCTION

68. 01 048 APPROPRIATE FREQUENCY DISTRIBUTIONS HAVE NEVER BEEN DEVELOPED FOR FOREST FIRE PHONOMENA: CONSEQUENTLY IT HAS NOT BEEN POSSIBLE TO COMPARE TIME PERIODS OR THE EFFECTS OF FIRE CONTROL ACTIVITIES. A. WHAT MATHEMATICAL FREQUENCY DISTRIBUTION(S) ARE APPROPRIATE FOR SUCH STATISTICS AS NUMBERS OF YEARS BY FIRE-OCCURRENCE AND AREA-BURNED CLASS, NUMBER OF FIRES BY FIRE-SIZE AND RATE-OF-SPREAD CLASS, AND THE LIKE? B. WHAT TECHNIQUES ARE VALID FOR COMPARING TIME PERIODS, EFFECTS OF TREATMENTS, ETC.? C. HAS MODERN FIRE CONTROL SIGNIFICANTLY ALTERED THE NATURAL FIRE REGIMEN?
EXPERIMENT ORIENTED QUESTION,FIRE DENSITY,FIRE STATISTICS

69. 01 048 CAN POST-GLACIAL FIRE HISTORY BE TRACED BY MEANS OF CHARCOAL COUNTS FROM LAKE AND BOG SEDIMENTS?
EXPERIMENT ORIENTED QUESTION,FIRE FREQUENCY,CHARCOAL,LAKE

70. 01 048 DID EXTENSIVE FOREST FIRES RESULT FROM POST-GLACIAL VOLCANIC ACTIVITY IN THE CASCADES?
EXPERIMENT ORIENTED QUESTION,VOLCANIC FIRE,FIRE HISTORY

71. 01 048 DOES FIRE SIGNIFICANTLY AFFECT POPULATIONS AND ACTIVITY OF PRIMARY AND SECONDARY FOREST INSECTS BY (A) MAKING FIRE-DAMAGED TREES MORE ATTRACTIVE AND/OR LESS RESISTANT TO ATTACK, (B) UPSETTING PREDATOR-PREY RELATIONSHIPS, (C) MODIFYING MICROCLIMATE, ETC.? (PARTICULARIZE BY TREE SPECIES.)
INSECT,PREDATION,MICROCLIMATE,POPULATION

72. 01 125 FOR GIVEN POPULATION DENSITIES OF ELK AND DEER, WHAT ARE THE OPTIMAL AREA SIZES AND SHAPES FOR CROWN-BURN SURROUNDED BY UNBURNED FOREST? HOW LARGE MUST A CROWN-BURNED AREA BE TO HAVE LITTLE VALUE AS A SUBSEQUENT FOOD SOURCE FOR THESE ANIMALS? FOR A GIVEN POPULATION DENSITY, DO SMALL BURNS DISPLAY RETARDED ECOLOGICAL SUCCESSION BY VIRTUE OF BEING OVER-BROWSED? WHAT IS THE RELATION BETWEEN BURN SIZE AND POPULATION DENSITY WHICH WOULD CAUSE THIS RETARDATION? GAME ANIMAL, POPULATION,AREA SIZE,MOSAIC,CROWN BURN,HERBIVORY,

73. 01 125 WHAT ARE THE COMPARABLE EFFECTS OF BROADCAST BURNING OF LOGGING SLASH VS. PILE-AND-BURN, AS SEEN IN ANIMAL PREDATION ON TREE SEEDS AND TREE REGENERATION? MANIPULATION COMPARISON,SEED,ANIMALS,REPRODUCTION

74. 01 125 WHAT ARE THE EFFECTS OF DIFFERENT DEGREES OF FUEL CONSUMPTION AS SEEN IN THE POPULATION DYNAMICS OF BURROWING SMALL MAMMALS? FUEL REDUCTION,SMALL MAMMAL,POPULATION

75. 01 125 WHAT IS THE EFFECT OF DIFFERENT DEGREES OF FUEL CONSUMPTION ON ANIMAL DAMAGE TO REGENERATING TREES OF VARIOUS SIZE CLASSES AND SPECIES? FUEL REDUCTION,ANIMALS,REPRODUCTION,SIZE CLASS

76. 01 125 WHAT IS THE EFFECT OF DIFFERENT DEGREES OF FUEL CONSUMPTION ON DENSITY OF VIABLE TREE SEEDS ON THE SOIL, IN TERMS OF SEED-GATHERING RODENT POPULATION DYNAMICS? FUEL REDUCTION,SEED,REPRODUCTION,PREDATION,SMALL MAMMAL

77. 01 125 WHAT IS THE EFFECT OF DIFFERENT SITE CONDITIONS (SOIL DEPTH, STRUCTURE, MOISTURE, SLOPE, EXPOSURE, SOIL NUTRIENTS, ETC.) ON VEGETATIVE RESPONSE OF ANNUALS, FORBS AND SHRUBS TO DIFFERENT FIRE INTENSITIES? FIRE INTENSITY, HERBAGE UNDERSTORY,SUCCESSION,CROWN BURN,SOIL,TOPOGRAPHY,NUTRIENTS

78. 01 125 WHAT IS THE EFFECT OF SLASH DISPOSAL BY BURNING, AS SEEN IN POPULATION DYNAMICS OF BIRDS? FUEL REDUCTION,BIRD,POPULATION

79. 01 125 WHAT MIGHT BE THE EFFECT OF CHANGING LEVELS OF DEBRIS ON POPULATION DYNAMICS OF GROUND-SURFACE WILDLIFE? HOW ARE THESE DYNAMICS CHANGED BY A FIRE, CONSIDERING DIFFERENT FUEL LOADS WILL INDUCE DIFFERENT FIRE RADIATION INTENSITIES, AND CAN POSSIBLY, THEN, CAUSE DIFFERENT SUCCESSIONAL RESPONSES IN THE VEGETATION? ANIMALS,POPULATION,FUEL/BIOMASS ACCUMULATION,FIRE INTENSITY,SUCCESSION

80. 01 127 DOES CONTROLLED BURNING PRODUCE A MEASURABLE EFFECT ON SNOW ACCUMULATION, SNOWMELT, AND TIMING AND MAGNITUDE OF PEAK RUNOFF? PRESCRIBED FIRE,SNOW,HYDROLOGY,STREAM

81. 01 127 WHAT IS THE EFFECT OF WILDFIRE (OR CONTROLLED BURNING) ON THE CHEMISTRY, TEMPERATURE, AND TURBIDITY OF WATER FLOWING FROM THESE AREAS AND HOW DO THESE CHANGES AFFECT FISH AND OTHER POPULATIONS? HOW LONG DO THE ABOVE EFFECTS LAST UNDER COMPLETE FIRE EXCLUSION? PRESCRIBED FIRE,NUTRIENTS,MICROCLIMATE,STREAM,FISH,ECOSYSTEM

82. 01 127 WHAT IS THE EFFECT OF WILDFIRE ON SNOW ACCUMULATION, SNOWMELT, AND TIMING AND MAGNITUDE OF PEAK RUNOFF? FIRE EFFECTS,SNOW,HYDROLOGY,STREAM

83. 01 221 SUGGESTED AREAS OF INQUIRY ARE: A COMPARATIVE STUDY OF WILDLIFE IMPACTS FROM LOGGING WASTE DISPOSAL BY BURNING VS. NON-BURNING METHODS. MANIPULATION COMPARISON,FUEL REDUCTION,ANIMALS

84. 01 222 THE RELEASE, ACCUMULATION, OR DESTRUCTION OF SOIL-PLANT NUTRIENTS APPEARS HIGHLY VARIABLE WITHIN A BURNED AREA. WHAT ARE THE EFFECTS ON SUBSEQUENT EFFORTS TO MODIFY HABITAT WITH SELECTED PLANT SPECIES?
NUTRIENTS,PLANTING

85. 01 222 WHAT ARE THE CONSEQUENCES OF HIGH ELEVATION (> 4000') BURNS ON SUBSEQUENT VEGETATION SUCCESSION WHERE THERE IS A SPARSE SEED SOURCE? PRIMARILY, WHAT ARE THE EFFECTS ON WILDLIFE?
SEED,REPRODUCTION,SUCCESSION,ANIMALS

86. 01 222 WHAT ARE THE EFFECTS OF NAPALM TYPE SLASH BURNS, OFTEN COVERING 100 ACRES, ON RESIDENT FAUNA? FIRE INTENSITY,AREA SIZE,ANIMALS

87. 01 222 WHAT EFFECT DOES PRE-BURN USE OF VEGETATION-DESSICATING CHEMICALS HAVE ON POST BURN VEGETATION? CHEMICAL RETARDANT EFFECTS,SUCCESSION

88. 01 222 WHY ARE GRASSES (SEEDED BY MAN) EMPHASIZED IN ROADSIDE OR ACCIDENTALLY BURNED AREA REVEGETATION, EVEN ON AREAS WHERE GRASSES ARE CONSIDERED DETRIMENTAL TO REFORESTATION AND PROVIDE POOR WILDLIFE BROWSE?
PLANTING,COMPETITION,ANIMALS,EXPERIMENT ORIENTED QUESTION

89. 01 226 ARE THERE STREAMS WHERE PRODUCTION COULD BE INCREASED BY FIRE OF THE RIGHT KIND (I.E., NOT LEADING TO EXCESSIVE EROSION AND STREAM SILTATION BUT RELEASING NUTRIENTS INTO THE STREAM)?
STREAM,ECOSYSTEM,FISH,NUTRIENTS

90. 01 226 I THINK IT IS IMPORTANT TO EVALUATE SHORT TERM AND LONG TERM EFFECTS OF FIRES OF DIFFERENT INTENSITIES. ONE WOULD EXPECT A CHANGE IN STREAM PH, FOR EXAMPLE, THAT MIGHT INITIALLY REDUCE STREAM PRODUCTION, BUT AT SOME STAGE OF RECOVERY , PRODUCTION MIGHT BE GREATER THAN BEFORE THE FIRE, DEPENDING ON SOIL COMPOSITION, THE TYPE OF VEGETATION BEFORE THE FIRE, ETC.. FIRE INTENSITY,PH,STREAM,PRODUCTIVITY

91. 01 226 I THINK THERE ARE IMPORTANT QUESTIONS RELATING TO FIRE FIGHTING THAT NEED TO BE EXAMINED MORE CLOSELY. ARE SOME OF THE FIRE RETARDANTS AND SPRAYS DAMAGING TO FISH PRODUCTION? DO THEY AFFECT THE FISH DIRECTLY WHEN THEY ENTER THE WATER OR DO THEY AFFECT FISH FOOD ORGANISMS? CHEMICAL RETARDANT EFFECTS,FISH,STREAM,INSECT,PRODUCTIVITY

92. 01 226 IS IT POSSIBLE TO USE FIRE TO MAINTAIN A DESIRABLE REGULATION OF DENSITY OF RIPARIAN VEGETAL COVER (E.G., WILLOWS OR ALDER) WHICH MIGHT ENHANCE PRODUCTION IN STREAMS WHERE TERRESTRIAL INSECTS ARE AN IMPORTANT FOOD SOURCE FOR FISH? FISH,STREAM,VEGETATION,INSECT

93. 01 226 WHAT IS THE EFFECT OF A CHANGE IN RUNOFF PATTERN ON THE CARRYING CAPACITY OF A STREAM? WHAT IS THE EFFECT ON PRODUCTION OF STREAM DRIFT ORGANISMS?
HYDROLOGY,STREAM,PRODUCTIVITY

94. 01 295 ARE FIRE SUPPRESSION PRACTICES ON SLOPE FORESTS ACCELERATING AQUATIC SUCCESSION PROCESSES AT OPEN SUBALPINE LAKE SYSTEMS WITH IMPORTANT RECREATIONAL VALUE? ECOSYSTEM,FIRE EXCLUSION,TOPOGRAPHY,SUCCESSION,HYDROLOGY,LAKE,RECREATION

95. 01 295 CERTAIN MONTANE LAKE SITES IN OLYMPIC NATIONAL PARK HAVE EVIDENTLY REDUCED FOREST LITTER ACCUMULATIONS DUE TO INTENSIVE CAMPING AND FIREWOOD GATHERING. GIVEN INCREASING RECREATION TRENDS WHAT MIGHT BE THE ECOLOGICAL EFFECTS OF LITTER REMOVAL IN MONTANE AND SUBALPINE SUBSYSTEMS? RECREATION,LITTER,FUEL/BIOMASS ACCUMULATION

96. 01 295 DOES FIRE SIGNIFICANTLY CREATE SUBALPINE MEADOWS IN MOIST CONIFEROUS ECOSYSTEMS SUCH AS THE OLYMPICS? GRASSLAND,SUCCESSION

97. 01 295 WHAT IS THE COMPOSITE ROLE OF WILDFIRE IN MOIST CONIFEROUS SYSTEMS SUCH AS OLYMPIC NATIONAL PARK? WHAT MANNER OF "FIRE POTENTIAL" BASELINE COULD SERVE AS A MANAGEMENT TOOL TO GUIDE AN EFFECTIVE ZONATION AND SELECTIVE CONTROL OF WILDFIRE, CONSISTENT WITH THE "NATURAL AREA" AND WILDERNESS POLICIES OF THE NATIONAL PARK SERVICE IN THIS AREA? GENERAL FIRE MANAGEMENT

98. 01 295 WHAT IS THE RELATIONSHIP IN WILDERNESS, MOIST CONIFEROUS SYSTEMS OF FIRE, AND OTHER PERTURBATIONS (AVALANCHES), TO THE DENSITY, DISTRIBUTION AND DYNAMICS OF THE UNGULATE COMPONENT OF THE BIOMASS (ROOSEVELT ELK AND BLACKTAIL DEER)? IN LOGGED-OVER LANDS THIS HAS BEEN STUDIED, BUT NOT TO MY KNOWLEDGE IN PRIMARY SUCCESSION CIRCUMSTANCES SUCH AS THE LARGELY UNDISTURBED (BY HUMANS) WET, WESTSIDE OF OLYMPIC NATIONAL PARK. SNOW,FUEL/BIOMASS ACCUMULATION,SUCCESSION,GAME ANIMAL,POPULATION,MANIPULATION COMPARISON

99. 01 390 ARE SNAGS BETTER LEFT STANDING OR DOWN IN AN OLD BURN WHEN CONSIDERING PROTECTION, SPREAD, INTENSITY, ETC. OF A SECOND BURN? SNAG,LIGHTNING-CAUSED FIRE,FIRE FREQUENCY,MANIPULATION COMPARISON,AESTHETICS

100. 01 395 APPARENTLY PODSOL SOILS ARE FORMED DURING FIRE. DOES THIS BREAK DOWN AFTERWARDS? WHAT EFFECT HAS THIS ON REGENERATION? SOIL,FIRE EFFECTS,REPRODUCTION,MICROCLIMATE,FIRE BEHAVIOR

101. 01 395 CAN SMOKE FROM WILDLAND FIRE BE CONSIDERED POLLUTION? SMOKE EFFECTS,AIR POLLUTION,FIRE EFFECTS

102. 01 395 DOES YARDING OF UNUTILIZED MATERIAL (YUM) SIGNIFICANTLY REDUCE FIRE POTENTIAL AND INTENSITY? FUEL REDUCTION,FIRE INTENSITY

103. 01 395 HOW MANY TONS ARE THERE IN A THOUSAND FEET OF REGULAR SLASH CONSISTING OF WESTERN RED CEDAR, HEMLOCK, DOUGLAS FIR, SILVER FIR,, ETC? FUEL/BIOMASS ACCUMULATION,CONIFEROUS FOREST,FUEL REDUCTION

104. 01 395 IS FIRE DAMAGE TO A STREAM PERMANENT OR TEMPORARY? HOW LONG DOES IT TAKE FOR A STREAM TO RECOVER? WHAT ABOUT LAKES? VALUE JUDGEMENT,STREAM,FIRE EFFECTS,TIMING

105. 01 395 IS SLASH BURNING AN AID OR A HINDRANCE TO REGENERATION? PRESCRIBED FIRE,FUEL REDUCTION,REPRODUCTION

106. 01 395 WHAT CAUSES FIRE "WHIRL WINDS" OR "FIRE DEVILS"? SOIL,FIRE EFFECTS,FIRE INTENSITY

107. 01 395 WHAT EFFECT DOES BURNED DUFF HAVE IN REGENERATION? REPRODUCTION,FIRE EFFECTS,DUFF

108. 01 395 WHAT EFFECT DOES FIRE HAVE ON THE DUFF LAYER IN REGARDS TO HARDENING OR ELIMINATING THE LAYER? DUFF,FIRE EFFECTS

109. 01 395 WHAT MAKES UP SMOKE? ISN'T SMOKE MOSTLY STEAM? SMOKE EFFECTS,AIR POLLUTION

110. 01 395 WHEN BURNING A SLASH UNIT, LET US SAY THE FUEL TYPES ARE M.M. HOW MUCH OR WHAT PERCENTAGE OF THE FUEL ON THE GROUND IS ACTUALLY CONSUMED BY FIRE UNDER NORMAL CONDITIONS? FUEL REDUCTION,PRESCRIBED FIRE,LITTER,DUFF,COMMUNITY

111. 01 396 DOES THE BURNING OF WINDROWS OR PILED SLASH IN CLEARCUTS CAUSE EXCESSIVE SOIL DAMAGE? IF SO, DOES THE INCREASED FUEL HAZARD REDUCTION COMPENSATE FOR THE LOSS OF PRODUCTION RESULTING FROM THE SOIL DAMAGE? PRODUCTIVITY,SOIL,PRESCRIBED FIRE,FUEL REDUCTION,PRODUCTIVITY,FIRE EFFECTS,NUTRIENTS

112. 01 396 HAVE WILDFIRES CREATED AND MAINTAINED HUCKLEBERRY FIELDS? WHAT TYPE OF MANAGEMENT IS NEEDED TO PERPETUATE THE HUCKLEBERRY- CONTROLLED BURNING- SELECT LOGGING, ETC? HOW MUCH SHADE CAN THEY TOLERATE? FIRE EXCLUSION,VEGETATION,GENERAL FIRE MANAGEMENT,RECREATION,PUBLIC REACTION,PRESCRIBED FIRE

113. 01 396 IS IT BETTER TO PLANT FIRE SPECIES (LARCH PONDEROSA PINE OR LODGEPOLE PINE) ON BURNED CLEARCUTS OR BURNS, OR IS IT BETTER TO PLANT THE SPECIES HARVESTED OR DESTROYED (DOUGLAS FIR, WHITE FIR OR SPRUCE)? PLANTING,COMMUNITY,FIRE EFFECTS,CONIFEROUS FOREST

114. 01 399 DO LARGE QUANTITIES OF ORGANIC MATERIAL SUCH AS CLEAR CUT SLASH HAVE DETRIMENTAL CHEMICAL EFFECTS ON THE SOIL? FUEL/BIOMASS ACCUMULATION,DECOMPOSITION,SOIL,NUTRIENTS

115. 01 399 DOES CONTINUED USE OF FIRE IN SLASH DISPOSAL REDUCE SOIL NUTRIENTS AND GRADUALLY DEPLETE A NATURAL DEVELOPMENT WITHIN THE SOIL? IS IT BETTER TO LEAVE ALL ORGANIC MATERIAL, SLASH,DUFF, ETC., FOR NATURAL DECOMPOSITION TO BUILD UP SOIL FERTILITY? TIMING,FUEL REDUCTION,PRESCRIBED FIRE,SOIL,NUTRIENTS,DUFF,LITTER,DECOMPOSITION

116. 01 399 DOES PRESCRIBED BURNING ON ISOLATED PATCHES, SUCH AS CLEARCUTS, HAVE ANY SIGNIFICANT IMPACT ON THE OVERALL ECOLOGICAL BALANCE OF A GIVEN AREA - E.G. A MUCH LARGER AREA THAN THE BURN ITSELF? PRESCRIBED FIRE,AREA SIZE,FUEL REDUCTION,ECOSYSTEM

117. 01 399 WHAT CHANGES IN EFFECT, IF ANY, ARE THERE BETWEEN CONTROLLED BURNING IN THE SPRING AND FALL AS NOW DONE AND THE NATURAL FIRES WHICH IN MANY CASES OCCURRED DURING EXTREME CONDITIONS? IS THERE ANY DETRIMENTAL, LASTING EFFECT ON THE CHEMICAL PROPERTIES OF SURFACE WATERS COMING FROM A BURNED AREA? PRESCRIBED FIRE,TIMING,FIRE HISTORY,FIRE EFFECTS,ECOSYSTEM

118. 01 399 WITHOUT USING FIRE, WHAT EFFECT CAN BE EXPECTED UPON PRESENT HABITATS DUE TO LONGTERM CHANGES IN VEGETATIVE GROWTH -SPECIES REGENERATED? FIRE EXCLUSION,SPECIES DIVERSITY,SUCCESSION,ECOSYSTEM

119. 01 400 IS THERE A RELATIONSHIP BETWEEN THE AMOUNT AND KIND OF REVEGETATION AND THE TIME OF YEAR A FIRE OCCURS? IF A FIRE OCCURS IN JULY OR AUGUST WHAT IS THE RELATIONSHIP TO ONE THAT OCCURS IN SEPTEMBER OR OCTOBER? FIRE EFFECTS,TIMING,REPRODUCTION

120. 01 400 WHAT ARE THE FIRE CHARACTERISTICS IN A DOZER-THINNED STAND OF TIMBER (USING A THINNING BLADE), WITH A CRUSHER, (TOMAHAWK) ATTACHED AND WITHOUT A CRUSHER, AS COMPARED TO AN UNTHINNED STAND OF THE SAME DENSITY AND SPECIES COMPOSITION? HUMAN DISTURBANCE,FIRE EFFECTS,FIRE INTENSITY,MANIPULATION COMPARISON,DENSITY

121. 01 401 WHAT ARE THE EFFECTS OF VARIOUS FIRE INTENSITIES ON SOIL STABILITY ON STEEP SLOPES IN HIGH RAINFALL AREAS? TOPOGRAPHY,SOIL EROSION,FIRE EFFECTS,FIRE INTENSITY

122. 01 402 HOW MUCH, IF ANY, IS A SITE INDEX CHANGED BY FIRE? POPULATION GROWTH,REPRODUCTION

123. 01 402 IS IT WISE TO FALL SNAGS IN OLD BURNS? DO THEY, ONCE FELLED, PROVIDE NEEDED SHADE FOR SEEDLINGS? SNAG,FIRE EFFECTS,REPRODUCTION,ECOSYSTEM

124. 01 402 WHAT IS THE BEST TIME OF YEAR TO BROADCAST BURN CLEARCUTS IN ORDER TO GET WELL ESTABLISHED CONIFEROUS PLANTATIONS? TIMING,PRESCRIBED FIRE,FUEL REDUCTION,REPRODUCTION,PLANTING

125. 01 402 WHAT IS THE COST/BENEFIT RATIO INVOLVED WITH "LET BURN" POLICY IN ALPINE TIMBER TYPES, E.G., IS FIRE LINE CONSTRUCTION AND RETARDANT MORE DETRIMENTAL THAN FIRE? CHEMICAL RETARDANT EFFECTS,ECONOMIC EFFECTS,MOUNTAIN,HUMAN DISTURBANCE,FIRE EFFECTS

126. 01 403 WHAT MIGHT BE THE EFFECTS OF BURNING ON ELK CALVING AREAS, IN REGARD TO HOW LONG ELK WILL STAY OUT OF AN AREA IF THEY DO, OR WILL THEIR PAST HABITS CHANGE AS A RESULT OF THE BURNING IMPACT? EXPERIMENT ORIENTED QUESTION,GAME ANIMAL,REPRODUCTION,DISPERSION,ANIMAL BEHAVIOR

127. 01 582 HOW DOES THE BURNING OF A FOREST SITE AFFECT THE ESTABLISHMENT AND EARLY GROWTH OF RED ALDER? FIRE EFFECTS,DECIDUOUS FOREST,REPRODUCTION,POPULATION

128. 01 582 HOW EFFECTIVE ARE HARDWOOD STANDS (PARTICULARLY RED ALDER) AS FIRE BREAKS? DECIDUOUS FOREST,FLAMMABILITY,GENERAL FIRE MANAGEMENT,POPULATION

129. 01 618 HOW WILL CONTROLLED BURNS AFFECT UNDERSTORY SPECIES COMPOSTION IN PONDEROSA FOREST CURRENTLY UNDERSTORIED WITH BITTERBRUSH BUT VERY LITTLE GRASS? SHRUB UNDERSTORY,CONIFEROUS FOREST,PRESCRIBED FIRE,SPECIES DIVERSITY

130. 01 618 IN SOUTH CENTRAL WASHINGTION HOW FREQUENTLY SHOULD PONDEROSA PINE BE SUBJECTED TO GROUND FIRES IN ORDER TO APPROXIMATE NATURAL CONDITIONS? TIMING,FIRE FREQUENCY,CONIFEROUS FOREST,GROUND FIRE,PRESCRIBED FIRE

131. 01 619 DID NATURAL FIRES OCCURING IN THE INTERIOR PONDEROSA PINE TYPE PRIOR TO IMPOSITION OF FIRE CONTROL HAPPEN WITH ANY DEGREE OF REGULARITY? IF SO, HOW OFTEN. SHOULD A STAND BE BURNED TO APPROXIMATE NATURAL CONDITIONS? FIRE FREQUENCY,PRESCRIBED FIRE,TIMING,LIGHTNING-CAUSED FIRE,COMMUNITY

132. 01 619 DO DIFFERENCES IN THE SEASON OF BURNING AND INTENSITY OF A BURN CAUSE ANY VARIATIONS IN THE COMPOSITION OF UNDERSTORY VEGETATION COMING IN AFTER THE FIRE? IF SO, CAN SUCH DIFFERENCES BE PREDICTED FOR BURNS AT DIFFERENT SEASONS AND LEVELS OF INTENSITY? FIRE EFFECTS,TIMING,PRESCRIBED FIRE,SPECIES DIVERSITY,FIRE INTENSITY,HERBAGE UNDERSTORY,SUCCESSION

133. 01 619 WE HAVE NOTED A TENDENCY FOR NOXIOUS WEEDS SUCH AS CANADA THISTLE AND DALMATION TOADFLAX TO INVADE FOLLOWING FIRE IN THE AREA. ARE THERE ANY WAYS TO HANDLE CONTROLLED BURNS TO AVOID THIS? PRESCRIBED FIRE,COMPETITION,SUCCESSION,FIRE EFFECTS

134. 01 621 CAN CONTROLLED FIRES BE USED IN SETTING BACK PLANT SUCCESSION TO MAINTAIN FOOD AND COVER AREAS FOR WILDLIFE AND YET RETAIN CONIFEROUS BLOCKS FOR TIMBER PRODUCTION? WHAT SIZED AREAS ARE ECONOMICALLY FEASIBLE? PRESCRIBED FIRE,SUCCESSION,ANIMALS,PRODUCTIVITY,AREA SIZE

135. 01 621 WHAT ADVERSE EFFECTS COULD BE ANTICIPATED FROM CONTROLLED FIRE ON LANDS THAT ARE SURROUNDED BY A SALT WATER BAY THAT IS A RICH ESTUARY SUSTAINING A RICH SHELLFISH CULTURE AND AQUATIC VEGETAL FOODS FOR WATERFOWL AND OTHER WILDLIFE? MY CONCERN HERE, IS RUN OFF EFFECTS. HOW LARGE A FIRE IT WOULD TAKE TO PRODUCE ADVERSE EFFECTS. PRESCRIBED FIRE,AREA SIZE,NUTRIENTS,SOIL EROSION,AQUATIC,BIRD,ANIMALS

136. 01 641 COULDN'T BOTH WILDLIFE AND TIMBER BENEFIT IN SOME AREAS IF CERTAIN TYPES OF FIRES ARE LEFT TO BURN AND NOT IMMEDIATELY SUPPRESSED "AT ANY COST"? I HAVE NO OBJECTION TO REMOVAL OF TIMBER, BUT COULDN'T SOME OF THE DEAD END ROADS BE CLOSED TO VEHICULAR TRAFFIC AFTER

COMPLETION OF THE SALE? DO WE NEED A ROAD ON EVERY RIDGE FOR FIRE SUPPRESSION? IN SHORT, I FEEL THERE IS ALREADY A SUFFICIENT AMOUNT OF KNOWLEDGE ON FIRE ECOLOGY TO CHANGE SOME OF THE PRACTICES AND BENEFIT WHOLE ECOSYSTEMS BUT IN THE END IT APPEARS THE DOLLAR AND THE FOUR WHEEL DRIVE PUBLIC IS DICTATING POLICY. ECONOMIC EFFECTS,FIRE EXCLUSION,WILDLIFE,HUMAN DISTURBANCE,PUBLIC REACTION,FIRE EFFECTS

137. 01 643 A 14,000 ACRE WILDLIFE-RECREATION AREA IN NORTH CENTRAL WASHINGTON IS MANAGED PRIMARILY AS A MULE DEER WINTER RANGE. MOST OF THE AREA IS A PONDEROSA PINE-BITTERBRUSH CLIMAX ASSOCIATION. CAN FIRE BE USED TO INCREASE RANGE PRODUCTION FOR DEER? WHAT EFFECT DOES FIRE HAVE ON SOIL MOISTURE CONTENT IN A 10-14 INCH RAINFALL AREA?
MICROCLIMATE,RECREATION,WILDLIFE,SHRUBLAND,GAME ANIMAL,FIRE EFFECTS,SOIL-WATER RELATIONS

138. 01 643 WHAT EFFECTS DOES FIRE HAVE ON MATURE BITTERBRUSH (PURSHIA TRIDENTATA) WHEN LOW INTENSITY GROUND FIRE CONTROLLED BURNING IS DONE IN THE FALL? FIRE EFFECTS,SHRUBLAND,TIMING,PRESCRIBED FIRE,FIRE INTENSITY

139. 01 643 WHAT EFFECTS WOULD FIRE HAVE ON OVERGRAZED OR IMPROPERLY GRAZED RANGELANDS IN A PONDEROSA PINE CLIMAX AREA? GRASSLAND,FIRE EFFECTS

140. 01 644 IN AN AREA WHERE FIRE WILL STIMULATE SHRUBS OR REGROWTH ON OLD PLANTS, WHAT IS THE OPTIMUM SIZE AND SHAPE OF BURNS THAT WILL BENEFIT WILDLIFE?
WILDLIFE,FIRE EFFECTS,AREA SIZE,PRODUCTIVITY,SHRUB UNDERSTORY

141. 01 644 WHAT ARE THE PARAMETERS FOR PREDICTING SPROUTING OF FIRE-INDUCED BROWSE PLANTS? PRODUCTIVITY,ORGAN,FIRE EFFECTS,SHRUB UNDERSTORY,SHRUBLAND

142. 01 644 WHAT CHANGES IN SPECIES COMPOSITION WILL TAKE PLACE IN GROUND AND SHRUB LAYERS WITH DIFFERENT FIRE INTENSITIES? FIRE INTENSITY,FIRE EFFECTS,SPECIES DIVERSITY,SHRUB UNDERSTORY,SUCCESSION

143. 01 644 WHAT EFFECT DOES FIRE INTENSITY HAVE ON NUTRIENT CONTENT OF RESPROUTING SHRUBS, AND WHAT IS THE CHANGE IN PRODUCTION OF SHOOTS BY LENGTH, NUMBER, OR DRY WEIGHT?
FIRE INTENSITY,FIRE EFFECTS,NUTRIENTS,SHRUB UNDERSTORY,PRODUCTIVITY,ORGAN

144. 01 644 WHAT IS THE SUCCESSIONAL PATTERN OF GROUND COVER PLANTS OF VARIOUS TYPES WITHIN THE CONIFEROUS FOREST BIOME? SUCCESSION,COMMUNITY,CONIFEROUS FOREST,FIRE EFFECTS

145. 01 644 WHAT IS THE SUCCESSIONAL PATTERN OF WILDLIFE RE-INVASION AND USE OF BURNED AREAS ON LARGE SCALE BURNS? AREA SIZE,FIRE EFFECTS,SUCCESSION,WILDLIFE

146. 01 715 FREQUENTLY A "NURSE CROP" IS AERIAL SEEDED SOON AFTER FIRE MOP-UP AND BEFORE REFORESTATION. HOW OFTEN IS THIS NURSE CROP EFFECTIVE IN DOING THE JOB INTENDED AND HOW OFTEN DOES IT BACKFIRE BY OFFERING TOO MUCH COMPETITION AND ADDING TOO MUCH FLASH FUEL TO THE SITE? MANIPULATION
COMPARISON,COMPETITION,REPRODUCTION,SEED,SOIL EROSION

147. 01 715 HOW DOES THE PROTEIN CONTENT OF SHRUBS ON REGENERATED BURNED AREAS COMPARE TO THOSE IN UNBURNED AREAS? THE CARBOHYDRATE CONTENT? DOES INTENSITY OF BURN HAVE A BEARING ON THIS? COMPOUNDS,NUTRIENTS,FIRE INTENSITY,FIRE EFFECTS,REPRODUCTION,PRODUCTIVITY

148. 01 715 TO WHAT EXTENT DO STREAM-SIDE FIRES CHANGE THE CHEMICAL COMPOSITION OF A STREAM? DOES INTENSITY OF BURN HAVE A BEARING ON THIS AND FOR HOW LONG? STREAM,NUTRIENTS,FIRE INTENSITY,FIRE EFFECTS

149. 01 715 WHAT ARE THE BENEFICIAL ASPECTS, IF ANY, OF A "NORMAL" FIRE CLIMAX FOREST IN THE INLAND EMPIRE REGION? SUCCESSION,FIRE EFFECTS,ECOSYSTEM

150. 01 715 WHAT EFFECT DOES FIRE HAVE ON ACQUATIC INSECTS? ARE SOME INSECTS MORE RESISTANT TO HABITAT CHANGE CAUSED BY FIRE THAN OTHERS? STREAM,INSECT,FIRE EFFECTS,COMMUNITY

151. 01 739 HOW CAN WE DEVISE A FIRE INFORMATION BASE THAT WILL HELP LAND MANAGERS BECOME UPDATED ON THE LATEST RELEVANT RESEARCH RESULTS AND NEEDS? FIRE EFFECTS

152. 01 740 WHAT VOLUME OF MERCHANTABLE TIMBER HAS BEEN LOST DUE TO EXCESSIVE COMPETITION FROM BRUSH SPECIES RESULTING FROM THE ACTIVE EXCLUSION OF FIRES IN FORESTS? PRODUCTIVITY,FIRE EXCLUSION,CONIFEROUS FOREST,COMPETITION,SHRUB UNDERSTORY

153. 01 741 MAJOR FOREST LAND MANAGEMENT AGENCIES ARE DISPOSING OF OLD GROWTH LOGGING SLASH BY BURNING UNDER THE ADDITIONAL CONSTRAINTS OF AIR POLLUTION REGULATIONS. WHAT IS THE EFFECT OF THESE CONSTRAINTS IN TERMS OF: A) ADDITIONAL SLASH DISPOSAL COSTS? B) ACREAGE OF SLASH UNBURNED DUE TO POLLUTION CONSTRAINTS? C) ACREAGE OF WILDFIRES AND SUPPRESSION COSTS RESULTING FROM BURNING SLASH WHEN AIR POLLUTION FACTORS ARE OPTIMUM BUT BURNING CONDITIONS FROM THE STANDPOINT OF CONTROL ARE NOT OPTIMUM? ECONOMIC EFFECTS,PRESCRIBED FIRE,FUEL REDUCTION, AIR POLLUTION,MICROCLIMATE,FIRE EFFECTS,PRESCRIBED FIRE

154. 01 741 ONE AGENCY ON MAJOR "EASTSIDE" FORESTS IN OREGON AND WASHINGTON IS STILL BURNING LARGE ACREAGES OF OLD GROWTH LOGGING SLASH IN PARTIAL CUT STANDS. OTHER AGENCIES MANAGING SIMILAR "EASTSIDE" FORESTS AND

PRACTICING SIMILAR CUTTING TREATMENTS ARE NOT. WHAT ARE THE EFFECTS OF THESE PRACTICES ON THE RATE OF SPREAD, RESISTANCE TO CONTROL OF WILDFIRE, AND SUPPRESSION COSTS ON THE RESPECTIVE AREAS? ECONOMIC EFFECTS,PRESCRIBED FIRE,FUEL REDUCTION,AREA SIZE,FIRE BEHAVIOR

155. 01 837 COULD LOGGING SLASH BE TREATED WITH SOMETHING THAT WOULD SPEED UP THE DECAY PROCESSES? HUMAN DISTURBANCE,DECOMPOSITION,FUEL REDUCTION

156. 01 837 DO YOU THINK THERE MIGHT BE A WAY TO AERIALLY TREAT SMOKE FROM A SLASH BURN TO MAKE IT SETTLE OUT FROM THE AIR SOONER, BEFORE IT DRIFTS TO AN AREA WHERE IT IS NOT WANTED? SMOKE EFFECTS,AIR POLLUTION,GENERAL FIRE MANAGEMENT,PUBLIC REACTION,PRESCRIBED FIRE,FUEL REDUCTION

157. 01 837 IN LOG STORAGE AREAS, OR IN A HEAVY SLASH AREA, WHEN A FIRE BURNS IN THIS SITUATION, HOW MUCH DAMAGE OCCURS TO THE SOIL, AND WHAT IS THE LASTING EFFECT, IF ANY? HUMAN DISTURBANCE,SOIL,FIRE EFFECTS,TIMING,PRESCRIBED FIRE

158. 01 837 IS IT POSSIBLE TO AERIALLY TREAT A SNAG AREA TO SPEED UP THE DECAY SO THEY WILL COME DOWN IN CHUNKS, INSTEAD OF ALL AT ONCE, AS THEY DO WHEN YOU FALL THEM? THIS QUESTION CONCERNS DOUGLAS FIR SNAGS. SNAG,HUMAN DISTURBANCE,DECOMPOSITION,CONIFEROUS FOREST,POPULATION,EXPERIMENT ORIENTED QUESTION

159. 01 837 WITH 180 TO 200 TONS OF SLASH PER ACRE AND A FALL SLASH BURN IS MADE, HOW MUCH SOIL DAMAGE TAKES PLACE? HOW MUCH OF THE SOIL NUTRIENTS ARE ADDED BACK TO THE SOIL BY THE WOOD ASH? ASH,FIRE INTENSITY,FIRE EFFECTS,SOIL,NUTRIENTS,PRESCRIBED FIRE,FUEL REDUCTION

160. 02 0000 CAN REPEATED FIRE EVENTUALLY LIMIT DESIRABLE BIG GAME BROWSE SPECIES SUCH AS REDSTEM CEANOTHUS? IF SO, HOW MUCH AND UNDER WHAT CONDITIONS? PRESCRIBED FIRE,FIRE FREQUENCY,SUCCESSION,SHRUBLAND,REPRODUCTION

161. 02 0000 IN THE IDAHO BATHOLITH, COMPARE THE EFFECTS OF SPRING (APRIL-MAY) BURNING SERAL BRUSHFIELDS ON SOIL, VEGETATION, WATER YIELDS AND QUALITY WITH SIMILAR EFFECTS OF: WILDFIRE IN MATURE FORESTS (WILDFIRE) BROADCAST BURNS FOR SLASH DISPOSAL, DOZER-PILED BURNS FOR SLASH DISPOSAL. HOW DO THESE EFFECTS CHANGE WITH SEASON OF BURNING? PRESCRIBED FIRE,SHRUBLAND,MANIPULATION COMPARISON,SOIL,VEGETATION,HYDROLOGY, FUEL REDUCTION

162. 02 0000 UNDER WHAT CONDITIONS IN THE IDAHO BATHOLITH DOES FIRE SIGNIFICANTLY INCREASE EROSION PROBABILITY? MASS FAILURE PROBABILITY? SOIL EROSION

163. 02 0000 WHAT ARE THE EXPECTED LONG-TERM EFFECTS OF REPEATED FIRE (FOR EXAMPLE AT INTERVALS OF 10, 20, 30 YEARS) ON THE GRANITIC SOILS, VEGETATION, WATER YIELD AND QUALITY IN THE IDAHO BATHOLITH? AT WHAT INTERVALS CAN BRUSHFIELDS BE REBURNED SAFELY FOR INCREASED BROWSE PRODUCTION IN THE IDAHO BATHOLITH? PRESCRIBED FIRE,FIRE FREQUENCY,SOIL STRUCTURE,SOIL EROSION

164. 02 129 DOES A UNIT WATERSHED HAVE CRITICAL AREAS WITH RESPECT TO FIRE DAMAGE? WATERSHED,AREA SIZE,MOSAIC,HYDROLOGY

165. 02 129 IS GROUND-COVER DAMAGE RELATED TO RATE OF FIRE SPREAD? FIRE BEHAVIOR,FUEL REDUCTION,FUEL/BIOMASS ACCUMULATION

166. 02 129 IS THERE A RELATION BETWEEN SOIL DEPTH AND GROUND-COVER DAMAGE FROM FIRES? SOIL,FUEL REDUCTION

167. 02 129 UNDER WHAT TOPOGRAPHIC CONDITIONS WILL SOIL DAMAGE FROM SUPPRESSION ACTIVITIES EXCEED DAMAGE FROM FIRE ALONE? MANIPULATION COMPARISON,GENERAL FIRE MANAGEMENT,FUEL REDUCTION,SOIL EROSION

168. 02 129 WHAT DEGREE OF ACCELERATED EROSION CAN BE EXPECTED AFTER FIRES OF DIFFERENT INTENSITY? FIRE INTENSITY,FUEL REDUCTION,SOIL EROSION

169. 02 130 WHAT ARE THE DIFFERENCES IN LITTER DECOMPOSITION AND ACCUMULATION RATES (BY KIND OF LITTER MATERIAL) BETWEEN BURNED-OVER SITES AND AREAS FROM WHICH FIRE WAS EXCLUDED? WHAT SPECIFIC DECOMPOSER ORGANISMS ARE INVOLVED? HOW DO THE DIFFERENCES IN RATES CHANGE WITH HABITAT TYPE, SPECIES COMPOSITION,STAND AGE, DENSITY, ETC.? HOW DOES FERTILIZATION (ESPECIALLY WITH N AND CA) AFFECT LITTER ACCUMULATION (NET) UNDER UNDISTURBED STANDS? MANIPULATION COMPARISON,FIRE EXCLUSION,LITTER,DECOMPOSITION,FUEL/BIOMASS ACCUMULATION,MICROORGANISM,SPECIES DIVERSITY,DENSITY,AGE,NUTRIENTS

170. 02 130 WHAT ARE THE POSSIBILITIES FOR DEVELOPMENT OF FIRE MEASUREMENT METHODS THAT CAN BE MORE EFFECTIVELY RELATED TO ECOLOGICAL EFFECTS AND SUBSEQUENT APPLICATIONS? GENERAL FIRE MANAGEMENT

171. 02 130 WHAT ARE THE RATES OF SLASH DETERIORATION (AND FIRE HAZARD REDUCTION) IN THINNED YOUNG STANDS AND PARTIALLY CUT OLDER STANDS? HOW ARE THESE AFFECTED BY HABITAT TYPE, SPECIES COMPOSITION,STAND AGE, DENSITY, THINNING INTENSITY, FERTILIZATION, SUPPLEMENTARY LOPPING AND SCATTERING, ETC.? ALSO, HOW ARE THESE RATES RELATED TO POTENTIALS FOR BUILDUP OF INSECTS AND DISEASES HARMFUL TO THE RESIDUAL STAND? HOW DO CHEMICALLY THINNED STANDS DIFFER IN FIRE SUSCEPTIBILITY AND DIFFICULTY OF FIRE CONTROL, FROM STANDS THINNED BY CUTTING? FUEL/BIOMASS ACCUMULATION,AGE,SPECIES DIVERSITY,DENSITY,NUTRIENTS,INSECT, DISEASE, FLAMMABILITY, MANIPULATION COMPARISON

172. 02 131 FIRE PREVENTION SINCE THE EARLY 1900'S HAS ALTERED THE FREQUENCY, INTENSITY, AND EXTENT OF FIRES IN WESTERN FORESTS. WHAT ARE THE ECOLOGICAL CONSEQUENCES OF THIS PROTECTION IN TERMS OF: (1) ALTERING THE RELATIVE PROPORTIONS OF SERAL AND CLIMAX VEGETATIVE CONDITIONS: (2) CHANGING THE RATES OF NUTRIENT CYCLING: (3) AFFECTING RATES OF ROCK WEATHERING AND SOIL FORMATION? FIRE FREQUENCY,FIRE INTENSITY,AREA SIZE,SUCCESSION,NUTRIENTS,SOIL

173. 02 131 INTENSIVE FOREST MANAGEMENT METHODS AND GOALS SUGGEST INCREASED SPACING BETWEEN TREES (I.E. FEWER TREES/ACRES), FASTER TREE GROWTH RATES, LESS FUEL PER ACRE, FREQUENT REENTRY INTO THE STANDS FOR LIGHT THINNING AND/OR HARVEST WITH LIGHT SLASH DEVELOPED. - WHAT EFFECT WOULD THIS SYSTEM OF MANAGEMENT HAVE ON: (1) FIRE SUPPRESSION ORGANIZATIONS AND PRACTICES: (2) NUTRIENT CYCLING WHEN COMPARED WITH (A) FREQUENT NATURAL AND UNCONTROLLED FIRE OCCURRENCE AND, (B) SUCCESSFUL FIRE PREVENTION AND/OR EARLY SUCCESSFUL SUPPRESSION ACTION? MANIPULATION COMPARISON,NUTRIENTS,FIRE FREQUENCY,FIRE EXCLUSION,PRODUCTIVITY,FUEL/BIOMASS ACCUMULATION

174. 02 133 DO FIRES OF VARYING INTENSITIES REDUCE THE INOCULUM OF ANY OF THE TREE OR SHRUB ROOT DISEASES? FIRE INTENSITY,ROOTS,DISEASE

175. 02 133 GIVEN POORLY, MODERATELY AND FULLY STOCKED STANDS, WHICH ARE MOST LIKELY TO BURN CLEANLY (OR CONVERSELY LEAVE SOME LIVING RESIDUALS) OVER THE RANGE OF POOR TO EXCELLENT SITES? E.G., DO POORLY STOCKED STANDS ON GOOD SITES BURN (OR WITH HIGHER PROBABILITY) MORE CLEANLY THAN DO SIMILARLY STOCKED STANDS ON POOR SITES, GIVEN EQUAL FIRE SITUATIONS? WHAT TYPE OF STAND, IF ANY, IS MOST LIKELY TO BE "FIRE-RESISTANT" ON ANY GIVEN SLOPE WITH ANY GIVEN FIRE FRONT? FIRE BEHAVIOR,POPULATION,DENSITY

176. 02 134 HOW SIGNIFICANT ARE VARIOUS INTENSITIES OF INSECT DEFOLIATION, OR TREE KILLING, IN INCREASING FIRE INTENSITY AND RATE OF SPREAD? INSECT,MORTALITY,FUEL/BIOMASS ACCUMULATION,FIRE BEHAVIOR

177. 02 134 A NUMBER OF DESTRUCTIVE AND BENEFICIAL INSECTS SPEND A PORTION OF THEIR LIFE, PARTICULARLY THE OVERWINTERING STAGES, IN THE DUFF. WHAT IS THE EFFECT OF CHANGES IN LITTER ACCUMULATION ON SURVIVAL AND DISTRIBUTION OF INSECTS THAT OVERWINTER IN THE DUFF? LITTER,FUEL/BIOMASS ACCUMULATION,FUEL REDUCTION,INSECT

178. 02 134 TREES STRUCK BY LIGHTNING OR WEAKENED BY FIRE ARE ATTRACTIVE TO BARK BEETLES , IMPORTANT TREE KILLERS. IN WHAT MANNER IS THE PHYSIOLOGY OF LIGHTNING STRUCK TREES CHANGED TO INCREASE THEIR ATTRACTIVENESS, OR REDUCE THEIR RESISTANCE, TO INFESTATION BY BARK BEETLES? LIGHTNING EFFECTS,INSECT,,EXPERIMENT ORIENTED QUESTION

179. 02 134 WHAT IS THE EFFECT OF INCREASING AREA SIZE OF EVEN-AGED TREES, AS RELATED TO THE PROBABILITY OF VARIOUS DENSITY LEVELS OF BARK BEETLE POPULATION? AREA SIZE,AGE,DENSITY,INSECT,POPULATION

180. 02 135 IN THE CONTROLLED BURNING OF AN AREA TO IMPROVE GAME RANGE, IS IT POSSIBLE TO SO TIME THE OPERATION SEASONALLY THAT A MAJOR REDUCTION IN THE WOODTICK POPULATION WOULD RESULT? PRESCRIBED FIRE,TIMING,INSECT,POPULATION

181. 02 136 DOES BURNING AFFECT THE RATE OF SOIL FORMATION DIFFERENTLY ON VARIOUS ASPECTS AND SLOPES? DOES BURNING AFFECT THE RATE OF SOIL FORMATION DIFFERENTLY UNDER CONIFER STANDS THAN UNDER BROADLEAVED SPECIES? DOES BURNING AFFECT THE RATE OF SOIL FORMATION THROUGH MICROFLORAL INTERMEDIARIES? SOIL STRUCTURE,SOIL-WATER RELATIONS,SOIL EROSION

182. 02 227 DO REPEATED BURNS TEND TO INFLUENCE THE SPECIES COMPOSITION OF THE SUBSEQUENT PLANT COMMUNITIES IN CONIFEROUS FORESTED AREAS AS FOUND IN NORTH CENTRAL IDAHO? FIRE FREQUENCY,SPECIES DIVERSITY

183. 02 227 HOW CAN FIRE BE USED MOST EFFECTIVELY IN MAINTAINING A SERAL DECIDUOUS PLANT COMMUNITY AT A SERAL STAGE MOST SUITABLE FOR MULE DEER AND ELK IN CONIFEROUS FORESTED AREAS AS FOUND IN NORTH CENTRAL IDAHO? SUCCESSION,GAME ANIMAL

184. 02 227 IS THE CREATION OF BRACKEN FERN STANDS RELATED TO THE DESTRUCTION OF THE "A"SOIL HORIZON BY FIRE? FIRE EFFECTS,FERN,SOIL

185. 02 227 WHAT AMOUNT OF GROUND COVER FUEL SUPPLY IS NEEDED TO CREATE THE TYPE FIRE NEEDED TO OBTAIN AN OPTIMUM DECIDUOUS SHRUB PLANT COMMUNITY FOR MULE DEER AND ELK IN TERMS OF PLANT SPECIES DENSITY, DISPERSION, AND COMPOSITION? --COULD A TOO LARGE FUEL SUPPLY ADVERSELY AFFECT THE ESTABLISHMENT OF SUCH A SERAL PLANT COMMUNITY, AND AT WHAT FUEL SUPPLY LEVEL WOULD THIS BE REACHED? SPECIES DIVERSITY,DISPERSION,FUEL/BIOMASS ACCUMULATION,SHRUBLAND,GAME ANIMAL,FIRE INTENSITY,REPRODUCTION

186. 02 227 WHAT EFFECT DO REPEATED BURNS IN AN AREA HAVE ON THE SEED SOURCE OF SUCH SPECIES AS WILLOW AND REDSTEM CEANOTHUS? FIRE FREQUENCY,SEED

187. 02 227 WHAT EFFECT DO VARIOUS SIZES AND TIMING OF BURNS HAVE ON THE GROWTH CHARACTERISTICS OF THE SUBSEQUENT STAGES OF THE DECIDUOUS SHRUB PLANT COMMUNITIES IN THE CONIFEROUS FORESTS OF NORTHERN IDAHO? AREA SIZE,FIRE FREQUENCY,SHRUBLAND,POPULATION GROWTH,FUEL/BIOMASS ACCUMULATION

188. 02 405 TO WHAT DEGREE OF RELIABILITY CAN FIRE FREQUENCY AND INTENSITY BE PREDICTED VIA AN IN-DEPTH ANALYSIS OF AN AREA'S FIRE HISTORY? FIRE HISTORY,FIRE FREQUENCY,MODEL

189. 02 405 WHAT SMALL ANIMAL AND BIRD POPULATIONS ARE MOST AFFECTED AND IN WHAT WAYS FOLLOWING LARGE INTENSE BURNS? SMALL MAMMAL,BIRD,COMMUNITY,FIRE EFFECTS,FIRE INTENSITY

190. 02 407 ARE THE HIGH SUBALPINE-AREA FIRES ESSENTIAL IN MAINTAINING BIGHORN AND MOUNTAIN GOAT SUMMER RANGES? GAME ANIMAL,FIRE EFFECTS,MOUNTAIN

191. 02 407 ARE THE SUCCESSIONAL STAGES OF LONGER DURATION FOLLOWING A REBURN? HOW IS THIS AFFECTED BY THE LENGTH OF TIME BETWEEN BURNS? FIRE FREQUENCY,SUCCESSION,TIMING,FIRE EFFECTS

192. 02 407 CAN A RELATIONSHIP BE ESTABLISHED BETWEEN FIRE OCCURRENCE AND INSECT EPIDEMICS IN WILDERNESS? THAT IS, DO LARGE FIRES HELP PREVENT INSECT EPIDEMICS? IS IT A CASE OF SUCCESSFUL FIRE SUPPRESSION ONLY MEANS THAT THE BUGS WILL TAKE THE TIMBER? FIRE EXCLUSION,FIRE EFFECTS,INSECT,AREA SIZE

193. 02 407 CAN SUCCESSION BE ACCURATELY PREDICTED FOLLOWING FIRE WITHIN ALL HABITAT TYPES AND AT ALL SUCCESSIONAL STAGES WITHIN THESE TYPES? SUCCESSION,MODEL,FIRE EFFECTS,ECOSYSTEM

194. 02 407 DOES THE SEASON OF BURNING GREATLY INFLUENCE THE EFFECT OF FIRE ON VEGETATION? DOES THE PHYSIOLOGICAL STAGE OF THE VEGETATION GREATLY INFLUENCE THE EFFECTS OF FIRE? FIRE EFFECTS,TIMING,COMMUNITY

195. 02 407 WHAT ARE THE CHEMICAL CHANGES IN LAKES AND STREAMS FOLLOWING BURNING? FIRE EFFECTS,LAKE,STREAM,NUTRIENTS

196. 02 407 WHAT ARE THE EFFECTS OF FIRE RETARDANT ON VEGETATION? CHEMICAL RETARDANT EFFECTS,VEGETATION

197. 02 407 WHAT IS THE EFFECT OF DIFFERENT WINDFALL DENSITY ON BIG GAME POPULATIONS? HOW IS WINDFALL DENSITY AFFECTED BY BURNING OR NOT BURNING? WINDFALL INCREASES WITH OVERMATURE STANDS OF TIMBER, BUT IT IS ALSO INCREASED BY SNAGS GOING OVER FOLLOWING A FIRE. GAME ANIMAL,FIRE EFFECTS,SNAG,WINDTHROW,WILDLIFE

198. 02 407 WHAT IS THE EFFECT OF FIRE ON MIGRATORY WILDLIFE SUCH AS BIRDS? DO POPULATIONS PRESENT PRECEDING FIRE RELOCATE AFTER BURNING IF CONDITIONS ARE NO LONGER SUITABLE FOR THEM? DO POPULATIONS MIGRATING THROUGH THE AREA STOP AS THEY FIND SUITABLE CONDITIONS? DO LARGE BURNS AFFECT THE MIGRATION ROUTES OF SMALL BIRDS? ANIMAL BEHAVIOR,BIRD,FIRE EFFECTS

199. 02 407 WHAT IS THE EFFECT OF FIRE RETARDANT ON AQUATIC LIFE IN STREAMS AND LAKES? DO TOLERANCE LEVELS VARY WITH DIFFERENT LAKES AND STREAMS? CAN THIS BE FORSEEN AND ALLOWED FOR? CHEMICAL RETARDANT EFFECTS,STREAM,LAKE,FISH,MODEL

200. 02 407 WHY DOES BITTERBRUSH (PURSHIA TRIDENTATA) RESPROUT FOLLOWING BURNING IN SOME INSTANCES AND NOT IN OTHERS? FIRE EFFECTS,REPRODUCTION,POPULATION GROWTH,SHRUB UNDERSTORY

201. 02 407 WILL FIRE CONTROL IN WILDERNESS AREAS RESULT IN LARGER AND MORE DISASTROUS FIRES IN THE FUTURE? FIRE EXCLUSION,AREA SIZE

202. 02 408 WHAT ARE ACTUAL EFFECTS OF PREVENTING, OR CONTROLLING AT CLASS A SIZE, NATURAL (LIGHTNING) FIRES ON PLANT AND ANIMAL SUCCESSION? LIGHTNING-CAUSED FIRE,AREA SIZE,SUCCESSION,VEGETATION,WILDLIFE,FIRE EXCLUSION

203. 02 409 SOMETIMES CONIFER SEEDLINGS PLANTED IN DEEP ASH BEDS WHERE HEAVY SLASH PILES ON WINDROWS WERE BURNED SHOW ACCELERATED EARLY GROWTH. IS THIS A SHORT TERM EFFECT, OR DO SUCH TREES REMAIN DOMINANT THROUGHOUT THE ROTATION? ASH,NUTRIENTS,REPRODUCTION,CONIFEROUS FOREST,FUEL REDUCTION,CHARCOAL,PRODUCTIVITY,PRESCRIBED FIRE,FIRE EFFECTS,EXPERIMENT ORIENTED QUESTION,POPULATION

204. 02 411 AT WHAT FREQUENCY CAN BROWSE BURNING ON KEY WINTER RANGE BE MADE WITHOUT CAUSING IRREVERSIBLE DAMAGE TO THE IMMEDIATE ENVIRONMENT? SHRUBLAND,WILDLIFE,PRESCRIBED FIRE,TIMING,FIRE FREQUENCY,FIRE EFFECTS

205. 02 411 HOW MUCH OF A TWO TO THREE INCH DUFF LAYER SHOULD BE REMOVED IN A BROADCAST BURN? UNDER WHAT CONDITIONS COULD SUCH REMOVAL BE OBTAINED? AT WHAT POINT WILL DUFF REMOVAL BY BROADCAST BURNING ADVERSELY AFFECT THE MICROCLIMATE OF THAT AREA AND WHAT IMPACT WOULD THAT HAVE ON THE OVERALL ENVIRONMENT OF THE AREA? FUEL REDUCTION,PRESCRIBED FIRE,DUFF,MICROCLIMATE,ECOSYSTEM

206. 02 411 IN A SHELTERWOOD, SELECTION OR OVERSTORY REMOVAL TYPE HARVEST, HOW MUCH, IF ANY, SLASH SHOULD BE LEFT IN THE AREA IN ORDER TO MAINTAIN THE NUTRIENT CYCLE WHEN "YARDING THE UNMERCHANTABLE TIMBER AND TOPS" IS A PART OF THE TREATMENT PRESCRIPTION? HUMAN DISTURBANCE,NUTRIENTS,FUEL REDUCTION,MANIPULATION COMPARISON

207. 02 411 IN THE PACIFIC NORTHWEST,HOW MANY YEARS ARE REQUIRED FOR FUELS ONE INCH AND UNDER TO DECOMPOSE TO THE POINT WHERE THEY CAN BE CONSIDERED PART OF THE DUFF LAYER? DUFF,DECOMPOSITION,CLIMATE,TIMING,ORGANISM

208. 02 411 IN VIEW OF THE FACT THAT A PUBLIC CRY IS BEING RAISED AGAINST PRESCRIBED FIRE, WHAT KIND OF FIRELESS FUEL MANAGEMENT IN RELATION TO TIMBER HARVESTING CAN BE EMPLOYED TO SIMULATE THE NATURAL ROLE OF FIRE? FIRE EXCLUSION,PRESCRIBED FIRE,MANIPULATION COMPARISON,PUBLIC REACTION,AIR POLLUTION,AESTHETICS,VALUE JUDGEMENT

209. 02 411 IS THE RESIDUE (ON LAYDOWN TREES) IN A PRECOMMERCIAL THINNING DETRIMENTAL TO SOIL CHEMISTRY? OR HOW MUCH LAYDOWN CAN BE TOLERATED BEFORE SOIL CHEMISTRY IS AFFECTED? NUTRIENTS,SOIL,HUMAN DISTURBANCE,FUEL/BIOMASS ACCUMULATION,DECOMPOSITION

210. 02 411 TO WHAT EXTENT DOES BROADCAST BURNING AFFECT THE PH OF ADJACENT STREAMS AND SOILS WITHIN THE BURN? PRESCRIBED FIRE,FIRE EFFECTS,PH,STREAM,SOIL,EXPERIMENT ORIENTED QUESTION

211. 02 411 WHAT ARE THE EFFECTS OF DOZER PILING ON SOIL COMPACTION AND PERMEABILITY? WHAT IS THE EFFECT OF COMPLETE DUFF REMOVAL ON THESE AREAS IN REGARDS TO SOIL FERTILITY OR NUTRIENT RECYCLING? AT PRESENT WE ARE REQUIRING 73% SOIL SCARIFICATION TO OBTAIN SEED BED PREPARATION. WOULD WE BE BETTER OFF TO REQUIRE LESS SCARIFICATION, FORGET ABOUT SEED TREE REGENERATION AND SPOT SCALP THE DUFF LAYER (2" AVERAGE) DURING A PLANTING OPERATION? SOIL STRUCTURE,PLANTING,HUMAN DISTURBANCE,MANIPULATION COMPARISON,NUTRIENTS,SEED,REPRODUCTION,DUFF

212. 02 411 WHAT IS THE BEST TIME TO PLANT AFTER A BROADCAST BURN? HOW DOES BURNING AFFECT SOIL MOISTURE DURING THE FIRST SUMMER AFTER BURNING? DOES THE BLACK SURFACE ABSORB MORE SOLAR HEAT AND THUS DRY OUT TO A DEPTH WHICH MIGHT CAUSE PLANTATIONS TO FAIL? MICROCLIMATE,CHARCOAL,ASH,SOIL-WATER RELATIONS,FIRE EFFECTS,PRESCRIBED FIRE,FUEL REDUCTION,PLANTING,TIMING,ECOSYSTEM

213. 02 413 WHAT IS THE COST/BENEFIT RATIO OF PERMITTING FIRE TO PLAY A NATURAL ROLE IF FIRE REACHES A POINT WHERE IT MUST BE SUPPRESSED? WHAT ARE SOCIO-ECONOMIC BENEFITS AND LOSSES? VALUE JUDGEMENT,FIRE EFFECTS,ECONOMIC EFFECTS,AESTHETICS,PUBLIC REACTION

214. 02 417 AT WHAT TEMPERATURES AND TEMPERATURE DURATION ARE SOIL MICROORGANISMS DECREASED TO A POINT TO PRECLUDE NATURAL TIMBER REGENERATION? CAN THIS BE RELATED TO DEAD FUEL DENSITIES ON A BASIS OF TONS PER ACRE PER SLOPE DEGREE? SOIL,MICROORGANISM,HEAT EFFECTS,FIRE EFFECTS,FUEL/BIOMASS ACCUMULATION,REPRODUCTION,TOPOGRAPHY

215. 02 417 FIRE OR HIGH TEMPERATURES ARE NECESSARY TO OPEN SEROTINOUS PINE CONES. AT WHAT TEMPERATURES ARE SEEDS DEHYDRATED OR OTHERWISE DAMAGED TO AN EXTENT TO PRECLUDE GERMINATION OR SURVIVAL OF GERMINANTS? OR DOES THIS OCCUR? CONIFEROUS FOREST,SEED,HEAT EFFECTS,FIRE EFFECTS,ORGAN

216. 02 417 IS THERE A POINT OF SOIL DAMAGE FROM FIRE WHERE LODGEPOLE PINE AND/OR DOUGLAS-FIR REGENERATION IS PRECLUDED BUT SOIL STABILIZATION WITH OTHER SPECIES CAN BE EXPECTED? THIS MAY BE IMPORTANT IN DETERMINING TIME LOSS IN PRODUCTIVITY OF TIMBER STAND WHILE NATURAL ECOLOGICAL SUCCESSION OCCURS. SUCCESSION,SOIL,HEAT EFFECTS,REPRODUCTION,CONIFEROUS FOREST,SOIL EROSION,PRODUCTIVITY,FIRE EFFECTS

217. 02 417 IT IS GENERALLY BELIEVED THAT LODGEPOLE PINE IS A FIRE CLIMAX SPECIES. HOWEVER, CONSIDERABLE ACREAGE IS OCCUPIED SOLELY BY THIS SPECIES WITH NO INVASION BY SPRUCE OR FIR. IS THIS RELATED TO INTENSITY OR FREQUENCY OF FIRE OR BOTH? OR, IS THE BASIC ECOLOGICAL CONCEPT IN ERROR? CONIFEROUS FOREST,SUCCESSION,COMPETITION,FIRE INTENSITY,FIRE FREQUENCY,POPULATION

218. 02 417 RECOGNIZING THAT SOMETIMES FIRE RESULTS IN SOIL LOSS AND RESULTANT DEGRADATION OF STREAM CHANNEL QUALITY, WHAT TIME FRAME CAN BE EXPECTED TO NATURALLY RESTORE STREAM REGIMEN TO A LEVEL TO SUPPORT FISHERIES AFTER THE WATERSHED HAS BEEN STABILIZED? CAN THIS BE ARTIFICIALLY REGENERATED THROUGH THE INTRODUCTION OF FERTILIZERS, MICROORGANISMS AND AQUATIC BIOTA? STREAM,FIRE EFFECTS,FISH,SOIL EROSION,TIMING,WATERSHED,NUTRIENTS,MICROORGANISM,ECOSYSTEM

219. 02 421 WHEN, WHERE, AND HOW CAN WE BEST USE FIRE TO RECLAIM FOREST OPENINGS INVADED BY CONIFERS IN THE ABSENCE OF FIRE, THEREBY IMPROVING WILDLIFE HABITAT IN THE NORTHERN ROCKY MOUNTAINS? COMPETITION,FIRE EXCLUSION,SPECIES DIVERSITY,WILDLIFE,SUCCESSION,COMMUNITY,PRESCRIBED FIRE,MOSAIC

220. 02 423 WHEN PREPARING A LODGEPOLE CLEARCUT UNIT FOR SLASH DISPOSAL WHERE CONE SEROTINY IS KNOWN TO EXIST, IS IT BETTER TO BROADCAST BURN OR WINDROW AND BURN THE SLASH? WILL EITHER RESULT IN BETTER REGENERATION OF SEEDLINGS? SEED,ORGAN,HUMAN DISTURBANCE,PRESCRIBED FIRE,FUEL REDUCTION,REPRODUCTION,CONIFEROUS FOREST

221. 02 428 WHAT IS A PRACTICAL AND ECONOMICAL MEANS OF ALLEVIATING THE NEGATIVE EFFECTS OF DEEP ASH BEDS IN OBTAINING NATURAL AND/OR ARTIFICIAL REGENERATION OF DOUGLAS-FIR IN THE INLAND EMPIRE? ASH,REPRODUCTION,FUEL REDUCTION,PLANTING,CONIFEROUS FOREST

222. 02 523 DOES LOGGING AND BURNING THE SLASH RESULT IN SIGNIFICANTLY LESS SOIL FERTILITY AND LOSS OF NUTRIENTS COMPARED TO AN AREA THAT HAS BEEN COMPLETELY BURNED? CAN NUTRIENTS LOST BECAUSE OF TIMBER REMOVAL BE REPLACED CHEAPLY BY APPLICATION OF COMMERCIAL FERTILIZER? MANIPULATION COMPARISON,NUTRIENTS,FIRE EFFECTS,FUEL REDUCTION,COMPOUNDS,HUMAN DISTURBANCE,SOIL

223. 02 584 WHEN IS THE OPTIMUM TIME TO DIRECT SEED AND/OR PLANT AFTER A SUMMER FIRE? TIMING,PLANTING,FIRE EFFECTS,CLIMATE

224. 02 646 TO WHAT DEGREE IS BITTERBRUSH REGENERATION LIMITED BY THE PLANTING OF VARIOUS COMPETITIVE GRASSES AS AN EROSION CONTROL FOLLOWING BURNS IN THE DOUGLAS FIR-MOUNTAIN BRUSH ZONES? FIRE EFFECTS,REPRODUCTION,COMPETITION,SOIL EROSION,PLANTING

225. 02 646 WHAT ARE SUCCESSION PATTERNS FOLLOWING SPRING AND FALL BURNING OF LODGE POLE PINE IN EASTERN IDAHO? PRESCRIBED FIRE,CONIFEROUS FOREST,SUCCESSION,TIMING

226. 02 646 WHAT IS BEST TIMING OF BURNS TO PRODUCE OPTIMUM REGENERATION OF BROWSE SPECIES IN DOUGLAS FIR STANDS? SHRUB UNDERSTORY,WILDLIFE,REPRODUCTION,PRESCRIBED FIRE,FIRE EFFECTS,CONIFEROUS FOREST

227. 02 647 HOW TO EVALUATE THE COSTS OF FIRE SUPPRESSION AND RESOURCE DESTRUCTION WITH EARTH MOVING EQUIPMENT AS COMPARED WITH TIMBER VALUES BEING DESTROYED IN WILDFIRE SITUATIONS? IN WHAT CASES WOULD IT BE CHEAPER TO LET A WILDFIRE BURN TO A NATURAL CONTROL LINE THAN TO SPEND WHATEVER NECESSARY TO CONTROL IT IMMEDIATELY? ECONOMIC EFFECTS,MANIPULATION COMPARISON,GENERAL FIRE MANAGEMENT

228. 02 649 CAN BRUSH FIELDS BE BURNED REPEATEDLY AT A FIVE TO TEN YEAR INTERVAL WITHOUT SERIOUS DAMAGE TO THE QUALITY OR FERTILITY OF THE SOIL? FIRE EFFECTS,FIRE FREQUENCY,SOIL,SHRUBLAND

229. 02 649 HOW IMPORTANT IS THE GROUND TEMPERATURE, CAUSED BY A FIRE, TO THE SOIL QUALITY AND FERTILITY? HEAT EFFECTS,SOIL,FIRE INTENSITY

230. 02 649 WILL REPEATED BURNS IN SHRUB COMMUNITIES CHANGE THE SPECIES COMPOSITION? FIRE FREQUENCY,FIRE EFFECTS,SHRUBLAND,SPECIES DIVERSITY

231. 02 823 HOW SERIOUS IS THE CRUSTING EFFECT OF THE FIRE ASH ON RETARDING SEEDLING ESTABLISHMENT? ASH,REPRODUCTION,SOIL STRUCTURE,ORGANISM

232. 02 823 IS IT MANDATORY TO COMPLETELY CONSUME THE HUMUS MANTEL TO DESTROY ROOTROT FUNGUS? FUEL REDUCTION,SOIL,ROOTS,FUNGUS

233. 02 823 TO WHAT EXTENT IS THE POTENTIAL SOIL EROSION HAZARD INCREASED BY A WILDFIRE? IN THE CASE OF A PRESCRIBED BURN ON A BRUSH FIELD? IN THE CASE OF A PRESCRIBED BURN ON A CLEARCUT? SOIL EROSION,PRESCRIBED FIRE,SHRUBLAND,MANIPULATION COMPARISON

234. 02 823 WHAT EFFECT DOES THE IMMEDIATE RELEASE OF NITROGEN AND OTHER PLANT NUTRIENTS HAVE ON THE SUCCESSFUL REGENERATION OF A STAND FOLLOWING A FIRE? HOW LONG ARE THE ABOVE MENTIONED ELEMENTS AVAILABLE TO NEW SEEDLINGS FOLLOWING THE FIRE? FIRE INTENSITY,NUTRIENTS,REPRODUCTION,SUCCESSION,ECOSYSTEM,TIMING

235. 02 823 WHAT EFFECT DOES THE LEACHING OF NUTRIENTS AND ASH INTO STREAMS HAVE ON THE FISHERIES? NUTRIENTS,ASH,STREAM,FISH

236. 02 823 WHAT IS THE EXTENT OF SMALL MAMMAL MORTALITY IN A FIRE WITH RELATIVELY COMPLETE CHARRING OF THE DUFF HORIZON? FUEL REDUCTION,SMALL MAMMAL,MORTALITY,POPULATION,LITTER

237. 03 020 DO "NATURAL" FOREST FIRES GENERALLY LEAD TO ACCELERATED NUTRIENT LOSSES FROM WATERSHEDS IN AREAS OF RELATIVELY LOW RAINFALL (30") AND, IF SO, FOR HOW LONG, IN WHAT FORM AND DO THESE LOSSES NOTICEABLY AFFECT LOW-ORDERED (1,2 AND 3) STREAMS? WOULD REMOVAL OF TREES BY OTHER MEANS, BUT WITHOUT LARGE SCALE MECHANICAL DISTURBANCE OF THE FOREST FLOOR, YIELD SIMILAR RESULTS?

ALSO, WILL FRUITION OF FULL-TREE UTILIZATION CONCEPTS IN THE ROCKIES, WHILE REDUCING SLASH DISPOSAL PROBLEMS, CREATE NUTRIENT BUDGETS THAT ARE NOT, QUANTITY-WISE OR TEMPORALLY, IN HARMONY WITH EVOLVED PROCESSES AND FUNCTIONING OF FORESTED ECOSYSTEMS?
NUTRIENTS,HYDROLOGY,MANIPULATION COMPARISON

238. 03 020 IS IT VALID TO ASSUME THAT CAREFULLY CONTROLLED CLEARCUTTING, OR GROUP SELECTION, MIMICS THE INTENSITY, EXTENT AND FREQUENCY OF "NATURAL" FIRE? HOW PERVASIVE ARE "EVEN-AGED" STANDS? MORE BROADLY, CAN FIRE BE MORE FULLY USED SILVICULTURALLY: IN THINNING, SPECIES CONVERSION, BROWSE DEVELOPMENT, AESTHETIC IMPROVEMENT, ETC.? MANIPULATION
COMPARISON,REPRODUCTION,COMPETITION,VEGETATION

239. 03 020 WITH THE DIVERSITY INHERENT IN LANDSCAPES LIKE THOSE OF ROCKY MOUNTAIN FORESTS, IS IT REASONABLE (POSSIBLE?) TO DEVELOP INVENTORY SYSTEMS AND REFINE MODELS WHICH PERMIT PREDICTION OF FIRE EXTENT PRIOR TO THE INITIATION OF SUPPRESSION? PARTICULARLY, COULD A PREDICTIVE SYSTEM BE DEVELOPED WITH ENOUGH RELIABILITY THAT MANAGERS AND THE PUBLIC WOULD ACCEPT THEIR USE ON SPECIFIC AREAS LIKE NATIONAL PARKS AND WILDERNESS AND PRIMITIVE AREAS? FIRE BEHAVIOR,PUBLIC REACTION

240. 03 021 IF A LAYER OF "TOPSOIL" IS APPLIED TO SURFACE-MINED AREAS DURING THE RECLAMATION PROCESSES, COULD THE BURNING OF A QUICK GROWING NURSERY CROP FOSTER THE GERMINATION OF RESIDUAL SEED OF FIRE CLIMAX NATIVE SPECIES MIXED IN THE TOPSOIL LAYER?
SEED,REPRODUCTION,SOIL

241. 03 021 WHAT ARE THE CONCURRENT AND SHORT TERM EFFECTS OF FIRE UPON MASS MOVEMENT OF DEBRIS DOWNSLOPE BY SUCH GRAVITATIONAL PROCESSES AS FALL, SLIDE, AND CREEP?
FUEL REDUCTION,SOIL EROSION

242. 03 021 WHAT EFFECT DOES FIRE HAVE ON ROCK WEATHERING?
FIRE INTENSITY,NUTRIENTS,ROCK

243. 03 023 WHAT ARE THE EFFECTS OF FIRE AND THE CONSEQUENCES OF FIRE, I.E., THE REMOVAL OF VEGETATION FROM AN AREA, ON THE POPULATIONS AND THE ACTIVITY OF THE TYPES OF BACTERIA KNOWN AS THE NITRIFIERS? THERE HAS BEEN SOME INTEREST IN THESE BACTERIA IN RECENT YEARS IN RELATION TO FOREST SOILS. IS IT POSSIBLE THAT THEIR ACTIVITY MAY HAVE SOME BEARING ON THE FERTILITY OF SOILS IN CLEARED AREAS? MICROORGANISM,NUTRIENTS,POPULATION

244. 03 023 WHAT IS THE EFFECT OF FIRE ON THE POPULATIONS OF FUNGI WHICH ACT AS MYCORRHIZAE AND, IF THERE IS ANY EFFECT, HOW DOES THIS RELATE TO THE REGENERATION OF YOUNG TREES?
POPULATION,FUNGUS,ROOTS,REPRODUCTION,VEGETATION

245. 03 025 CAN FIRE BE USED TO MAINTAIN A STAND OF SERVICEBERRY, CHOKECHERRY, MTN MAPLE, AND CEANOTHUS IN VIGOUROUS CONDITIONS? PRODUCTIVITY,SHRUBLAND

246. 03 025 HOW CAN FIRE BE USED AS A MANAGEMENT TOOL FOR IMPROVING WINTER BIG GAME RANGES (IN PARTICULAR MIXED SHRUB-GRASS-FORB COMMUNITIES)? GAME ANIMAL,PRODUCTIVITY,HERBAGE UNDERSTORY,SHRUBLAND

247. 03 025 WHAT DOES FIRE DO TO THE NUTRIENT CHARACTERISTICS OF KEY SHRUBS AND RESULTANT PALATABILITY AND USE PATTERNS BY HERBIVORES? NUTRIENTS,SHRUBLAND,HERBIVORY

248. 03 055 COULD NOT GREAT EDUCATIONAL BENEFITS (PUBLIC) BE DERIVED FROM PROGRAMS TO INTERPRET ONGOING WILDFIRES? LIGHTNING STORMS & WILDFIRE, IF VIEWED IN THE PROPER PERSPECTIVE, CAN BE SEEN AS IMPRESSIVE & BEAUTIFUL MANIFESTATIONS OF THE NATURAL WORLD. NEITHER ARE INTRINSICALLY BAD OR EVIL. WHILE NOT ALL LIGHTNING FIRES CAN BE PERMITTED TO BURN, EDUCATIONAL OPPORTUNITIES EXIST WITH ALL BURNS. YET VERY LITTLE IS DONE BY RESPONSIBLE AGENCIES TO UTILIZE THE OPPORTUNITIES. SOCIAL EFFECTS,PUBLIC REACTION

249. 03 055 HOW ARE THE AESTHETIC QUALITIES OF WILD AREAS AFFECTED BY SUPPRESSION ACTIVITIES WHICH LEAVE LONG TERM EVIDENCE OF SUCH ACTIVITIES (BULLDOZER USE, GARBAGE DUMPS FROM FIRE CAMPS, ETC.)? AESTHETICS,GENERAL FIRE MANAGEMENT

250. 03 055 MANY SCIENTISTS NOW BELIEVE THAT FIRE IN THE FOREST ECOSYSTEM IS AN ECOLOGIC FACTOR OF UNSURPASSED SIGNIFICANCE AND IS TO A LARGE DEGREE RESPONSIBLE FOR "MOLDING" MUCH OF THE PRESENT BIOTA, YET GOV'T AGENCY PROGRAMS CONTINUE TO EMPHASIZE FIRE'S DESTRUCTION OF LAND. A REORIENTATION OF AGENCY EDUCATIONAL AND OPERATIONAL PROGRAMS IS DESPERATELY NEEDED. SOCIAL EFFECTS,PUBLIC REACTION

251. 03 055 WHAT ARE THE ECOLOGICAL CONSEQUENCES OF SUPPRESSION ACTIVITIES, PARTICULARLY BULLDOZER USE? HAS NOT THE USE OF BULLDOZERS PRODUCED LONG TERM ECOLOGICAL DETERIORATION IN AFFECTED ECOSYSTEMS-AT LEAST IN AREAS OF THIN SOIL & STEEP TERRAIN? GENERAL FIRE MANAGEMENT,SOIL

252. 03 055 WHAT ARE THE ECOLOGICAL RELATIONSHIPS BETWEEN FIRE & HUCKLEBERRIES IN THE NORTHERN ROCKIES? VACCINIUM SPP. ARE IMPORTANT IN TERMS OF AESTHETIC VALUES & BERRY PRODUCTION. IS FIRE EXCLUSION DIMINISHING THEIR ABUNDANCE? TO WHAT EXTENT ARE THEY DEPENDENT UPON FIRE FOR PERPETUATION? SHRUBLAND,PRODUCTIVITY,FIRE EXCLUSION,AESTHETICS

253. 03 055 WHAT IS THE PUBLIC ATTITUDE TOWARDS THE NATURAL ROLE OF FIRE IN ECOSYSTEMS? CAN THE SMOKEY BEAR SYNDROME BE TEMPERED BY EDUCATIONAL PROGRAMS, BOTH WITH LAND MANAGERS & THE PUBLIC? PUBLIC REACTION

254. 03 055 WHAT SONG BIRDS IN THE NORTHERN ROCKIES REQUIRE BURNED AREAS DURING SOME PORTION OF THE YEAR? WHAT ATTRIBUTES OF BURNED AREAS ARE ESSENTIAL FOR SUCH SPECIES? BIRD,EXPERIMENT ORIENTED QUESTION

255. 03 055 WHAT UNIQUE ECOLOGICAL ROLES ARE FILLED BY FIRE KILLED SNAGS? WHAT TREE SPECIES PRODUCE SNAGS MOST-USED BY BIRDS? SNAG,BIRD

256. 03 055 WITH THE ECOLOGICAL IMPORTANCE OF FIRE SEEMINGLY RECOGNIZED BY FEDERAL AGENCIES, WHY DOES THE SMOKEY BEAR PROPAGANDA MACHINE DRONE ON WITH THE IMPLICATION THAT FIRE IS INHERENTLY BAD AND THAT "LAND" IS DESTROYED BY FIRE? VALUE JUDGEMENT,PUBLIC REACTION

257. 03 109 CAN CONTROLLED BURNING BE USED TO REJUVENATE DECADENT STANDS OF SHRUBS ON BIG GAME WINTER RANGE? HOW DO SHRUBS RESPOND TO BURNING AT VARIOUS AMOUNTS OF FINE FUEL IN THE UNDERSTORY, AND ON VARIOUS SOIL TYPES? WHAT ARE THE RESPONSES AS EXPRESSED IN NUMBER AND LENGTH OF NEW SPROUTS (INITIAL RESPONSES AND MORTALITY/SURVIVAL LATER), HERBAGE PRODUCTION, AND CHEMICAL CONTENT OF NEW GROWTH? PRESCRIBED FIRE,SHRUBLAND,REPRODUCTION,PRODUCTIVITY,STEM,MORTALITY, HERBAGE UNDERSTORY,NUTRIENTS,GAME ANIMAL

258. 03 109 HOW DOES FIRE SUPPRESSION AFFECT THE AMOUNT OF WINTER RANGE AVAILABLE TO MULE DEER, WHITETAIL DEER, AND ELK HERDS? CAN A "LET BURN" POLICY BE DEVELOPED TO MAINTAIN PRESENT WINTER RANGES AND DEVELOP NEW ONES? FIRE EXCLUSION,GAME ANIMAL,PRODUCTIVITY

259. 03 109 HOW DOES THE BURNING OF SLASH, FOLLOWING LOGGING PRACTICES, RELATE TO SUBSEQUENT SOIL EROSION AND STREAM SILTATION? HOW DOES THE BURNING OF PILES OF SLASH AFFECT THE STRUCTURE, ORGANIC MATTER, WATER HOLDING CAPACITY, CHEMICAL CONTENT, AND ERODIBILITY OF THE SOIL BENEATH THE SLASH PILES? FUEL REDUCTION,FUEL REDUCTION,SOIL EROSION,STREAM

260. 03 109 WHAT IS THE DEVELOPMENTAL AND SUCCESSIONAL PATTERN OF UNDERSTORY PLANT COMMUNITIES FOLLOWING FIRES OF VARIOUS CHARACTERISTICS? SUCCESSION,HERBAGE UNDERSTORY,SHRUB UNDERSTORY

261. 03 119 HOW CAN ENVIRONMENTAL FACTORS (HABITAT COMPLEXITY, SPECIES COMPOSITION, ETC.) BE MANIPULATED TO CONTROL THE SUCCESSIONAL SMALL MAMMAL FAUNA? SPECIES DIVERSITY,SUCCESSION,SMALL MAMMAL,FUEL REDUCTION,PRESCRIBED FIRE

262. 03 119 HOW IS IT POSSIBLE THAT SOME FOREST TYPES OF LIMITED FIRE EXPERIENCE (FUEL REDUCTION) SUCH AS ENGLEMAN SPRUCE-SUBALPINE FIR HAVE REACHED CONSIDERABLE AGE AND SIZE BUT ARE AT TIMES WIPED OUT AND REPLACED BY LODGEPOLE PINE? THIS MIGHT BE STATED DIFFERENTLY, I'M NOT SURE HOW. FIRE FREQUENCY,SUCCESSION

263. 03 119 IN PARTICULAR, IT WOULD BE DESIRABLE TO EXAMINE THE POSSIBLE CONDITIONS WHICH HAVE LED UP TO SOME OF THE LARGE FIRES IN THE NORTHERN ROCKIES SUCH AS THE 1910 FIRE, THE PETE KING FIRE, THE SUN DANCE FIRE AND OTHERS. WERE THESE LARGE BECAUSE OF FIRE PROTECTION AND CONSEQUENT FUEL BUILD UP? FIRE EXCLUSION,FIRE HISTORY,FUEL/BIOMASS ACCUMULATION

264. 03 119 UNDER WHAT CONDITIONS (TYPES OF BURN AND CUTTING COMBINATIONS) DOES THE WOODMOUSE (PEROMYSCUS LEUCOPUS) EXHIBIT INCREASED POPULATION DENSITIES AND SUBSEQUENTLY CAUSE SEED AND SEEDLING LOSS? MANIPULATION COMPARISON,SMALL MAMMAL,POPULATION,DENSITY,SEED,REPRODUCTION

265. 03 123 DOES A WILDFIRE BECOME A MORE DESTRUCTIVE PROCESS IN FORESTS THAT ARE SIMULTANEOUSLY INFLUENCED BY INSECTS AND/OR FUNGI PATHOGENS? INSECT,FUNGUS

266. 03 123 HOW ARE NON-FIRE-DEPENDENT TREE SPECIES INFLUENCED BY NON-DESTRUCTIVE GROUND FIRES? GROUND FIRE

267. 03 123 WHAT IS THE ACTUAL RATE OF ORGANIC FUEL ACCUMULATION IN CONIFEROUS FOREST BIOMES (MONTANA AND IDAHO)? ARE THESE RATES VARIABLE BETWEEN 0-200 YEARS FOLLOWING FIRE DISTURBANCE? DO FUEL ACCUMULATIONS AFFECT THE RATE OF PRODUCTIVITY OF TREES, SHRUBS AND HERBS? IF SO, IS THERE A CRITICAL POINT THAT CAN BE IDENTIFIED? FUEL/BIOMASS ACCUMULATION,PRODUCTIVITY,SHRUB UNDERSTORY,HERBAGE UNDERSTORY

268. 03 123 WHAT IS THE BASIC LANDSCAPE MOSAIC (VEGETATIONAL LIFE-FORM COMPLEX) THAT WILL EXHIBIT FIRE CONTROL OR CONTAINMENT PROPERTIES ON A GIVEN TOPOGRAPHIC SITE? HOW CAN A MOSAIC EFFECT BE MEASURED? MOSAIC,FIRE BEHAVIOR,FLAMMABILITY

269. 03 123 WHAT SPECIES OF ANIMALS ARE SPECIFICALLY AFFECTED BY THE GRADUAL REDUCTION OF PLANT COMMUNITY LIFE-FORM DIVERSITY? ANIMALS,SPECIES DIVERSITY

270. 03 137 COULD LOGGING SIMULATE THE EFFECTS OF NATURAL FIRES? IF SO, HOW CAN THIS BEST BE ACCOMPLISHED IN VARIOUS REPRESENTATIVE HABITAT TYPES, KEEPING FINANCIAL CONSTRAINTS IN MIND? MANIPULATION COMPARISON

271. 03 137 WHAT ARE THE PATTERNS AND EFFECTS OF LITTER ACCUMMULATION AND FUEL BUILDUP WITH FIRE SUPPRESSION IN REPRESENTATIVE CONIFEROUS FOREST COMMUNITIES (HABITAT TYPES) IN THE NORTHERN ROCKIES? HOW WILL FIRE EXCLUSION AFFECT VIGOR, DISEASE RESISTANCE, AND REGENERATION OF A VARIETY OF SIVICULTURALLY MANAGED STANDS? (USING OUR LOW-INTENSITY SILVICULTURE AS THE REFERENCE POINT) FIRE EXCLUSION,LITTER,FUEL/BIOMASS ACCUMULATION,PRODUCTIVITY,DISEASE,REPRODUCTION

272. 03 138 HOW DOES USE OF POST-HARVEST PRESCRIBED FIRE AFFECT SOIL CHARACTER, HYDROLOGY, NUTRIENT BALANCE & OFF-SITE TRANSPORT OF NUTRIENTS? HOW DOES THIS INTERRELATE WITH VOLUME OF RESIDUE MATERIAL LEFT ON GROUND TO BURN? UNDER INTENSIVE RESIDUE UTILIZATION PRACTICES, THERE WILL BE LITTLE LEFT ON THE AREA TO BURN. PRESCRIBED FIRE,SOIL,HYDROLOGY,NUTRIENTS,FUEL REDUCTION,FUEL REDUCTION

273. 03 138 HOW MUCH IMPACT DOES FIRE POLICY (EXCLUSION, CONTROL, PRESCRIBED FIRE, SLASH REDUCTION PRACTICES, ETC.) HAVE ON THE DEVELOPMENT AND ACCUMULATION OF WOOD RESIDUES IN ROCKY MOUNTAIN TIMBER TYPES? (RESIDUES TO INCLUDE ALL DEAD MATERIAL, AS WELL AS LOGGING OR THINNING SLASH). GENERAL FIRE MANAGEMENT,FUEL/BIOMASS ACCUMULATION

274. 03 138 MOST HARVESTING PRACTICES RESULT IN RE-ARRANGING AND RE-DISTRIBUTING FUELS-- FOR EXAMPLE, SKYLINE ROADS MAY HAVE HEAVY ACCUMULATIONS OF LIGHT FUELS UNDER THE SKYLINE, WITH VERY LITTLE LEFT OUT BETWEEN SKYLINE SETTINGS. IF POST-HARVEST SITE TREATMENT INCLUDES BURNING, WHAT EFFECTS WILL THE FUEL DISTRIBUTION PATTERN HAVE ON SOILS, HYDROLOGY, NUTRIENT AVAILABILITY, MICROBIAL ACTIVITY, & OTHER BIOLOGICAL ATTRIBUTES? MANIPULATION COMPARISON,FUEL/BIOMASS ACCUMULATION,MOSAIC,ZONATION,SOIL,HYDROLOGY,NUTRIENTS

275. 03 138 WILL EXCLUSION OF POST-HARVEST (LOGGING) USE OF FIRE (WHICH MAY BE NECESSITATED IF RESIDUE UTILIZATION IS INTENSIVE) HAVE SERIOUS EFFECTS UPON STAND REGENERATION? IF SO, IS THERE A NEED TO PRESCRIBE RESIDUE UTILIZATION STANDARDS IN SUCH A MANNER THAT SOME FUELS ARE LEFT ON-SITE TO CARRY A FIRE? FIRE EXCLUSION,FUEL REDUCTION,REPRODUCTION,COMMUNITY

276. 03 140 WHAT IS THE NATURE AND RATE OF ORGANIC MATTER ACCUMULATION AND DECOMPOSITION ON DIFFERENT NORTHERN ROCKY MOUNTAIN FORESTED ECOSYSTEMS? HOW DO THEY CHANGE WITH STAND AGE? HOW ARE THEY AFFECTED BY PERIODIC, CATASTROPHIC AND ENDEMIC INFLUENCES LIKE DISEASE, INSECT AND WINDTHROW? (A LONG-TERM MODEL WILL PROBABLY BE NEEDED FOR AT LEAST 10 TYPES. ALSO, AVERAGE FIRE FREQUENCY WILL NEED TO BE TIED TO EACH TYPE.) FUEL/BIOMASS ACCUMULATION,AGE,DISEASE,INSECT,WINDTHROW,FIRE FREQUENCY

277. 03 142 ARE BRUSH CYCLES NECESSARY TO SUCCESSFUL REGENERATION OF CONIFER STANDS ON SITES WITH SEVERE OR DRY EXPOSURES? SHRUBLAND,REPRODUCTION

278. 03 142 ARE PERIODIC FIRES NEEDED TO MAINTAIN PATHOGEN POPULATIONS IN PROPER BALANCE WITH OTHER COMPONENTS OF THE ECOSYSTEM, OR MORE SPECIFICALLY, ARE PERIODIC SANITIZING EFFECTS OF FIRE NEEDED TO MAINTAIN HEALTHY GROWTH OF TREES? FIRE FREQUENCY,DISEASE

279. 03 142 CONSIDERING MANY ROTATIONS, HOW MUCH TREE MATERIAL SUCH AS NEEDLES AND BRANCHWOOD SHOULD BE LEFT IN THE FOREST AFTER HARVESTING IN ORDER TO FURNISH NUTRIENTS TO THE SUCCEEDING FOREST CROP WITHOUT LONG-TERM LOSS OF PRODUCTIVITY? WHEN MINIMUM AMOUNTS OF RESIDUE ARE LEFT, IS FIRE TREATMENT DESIRABLE OR UNDESIRABLE? FUEL REDUCTION,NUTRIENTS,PRODUCTIVITY,MANIPULATION COMPARISON

280. 03 142 HOW LONG CAN ROCKY MOUNTAIN BRUSHFIELDS BE KEPT IN BRUSH USING REPEATED FIRE WITHOUT REDUCTION IN PLANT AND ANIMAL PRODUCTIVITIES? SHRUBLAND,FIRE FREQUENCY,SUCCESSION,PRODUCTIVITY

281. 03 142 HOW SIGNIFICANT IS PERIODIC FIRE IN THE A. CARBON CYCLE, AND B. NUTRIENT CYCLE IN A FOREST STAND? FIRE FREQUENCY,NUTRIENTS

282. 03 142 IF FIRE IS ABSENT FROM ROCKY MOUNTAIN FORESTS FOR MANY TIMES THE NORMAL FIRE FREQUENCY, WILL A. DEAD FUEL ACCUMULATION ON THE FOREST FLOOR BALANCE DECOMPOSITION, AND B. WILL PRODUCTIVITY BE REDUCED, EVEN IF NEW STANDS ARE PLANTED? FIRE EXCLUSION,FUEL/BIOMASS ACCUMULATION,DECOMPOSITION,PRODUCTIVITY

283. 03 142 WHAT ARE THE RELATIONSHIPS BETWEEN FIRE INTENSITY AND BURN DURATION AND: A. AVAILABILITY OF ESSENTIAL PLANT NUTRIENTS B. LOSS OF ESSENTIAL PLANT NUTRIENTS FROM UPPER SOIL LAYERS C. POPULATION DYNAMICS OF SOIL FUNGI AND BACTERIA D. POPULATION DYNAMICS OF SOIL FAUNA. FIRE INTENSITY,TIMING,NUTRIENTS,SOIL,FUNGUS,MICROORGANISM

284. 03 142 WHAT MAN-MADE ACCUMULATIONS, SUCH AS SLASH FROM HARVESTING, WILL, IF PRESCRIBED BURNED, RESULT IN SOIL DAMAGE AND IMPAIRMENT OF SITE QUALITY? FUEL REDUCTION,SOIL,PRESCRIBED FIRE

285. 03 145 IS THERE AN OPPORTUNITY TO USE FIRE MANAGEMENT IN THE POSSIBLE CONTROL OR MANIPULATION OF INSECT POPULATIONS WHICH MAY SPEND ALL OR PART OF THEIR LIFE CYCLE IN THE LITTER OR DUFF OR EVEN ON LOW GROWING VEGETATION? INSECT,LITTER

286. 03 145 MANY SPECIES OF FOREST INSECTS DO THEIR BEST WITHIN DYING OR WEAKENED MATERIAL. WHAT EFFECT DO TREES DAMAGED OR WEAKENED BY FIRE HAVE IN THE DEVELOPMENT OF OUTBREAKS OF THOSE SPECIES OF FOREST INSECTS WHICH DEPEND ON WEAKENED OR DYING MATERIAL TO DEVELOP? MORTALITY,INSECT,POPULATION

287. 03 145 WHAT INFLUENCE MIGHT EXTENSIVE AREAS OF FORESTS KILLED OR SEVERELY DEFOLIATED BY FOREST INSECTS HAVE ON DECISIONS CONCERNING FIRE SUPPRESSION OR FIRE EXCLUSION. (A GOOD SHARE OF THE SLEEPING CHILD FIRE IN THE BITTERROOT NOT TOO LONG AGO ROARED THROUGH STANDS OF LODGEPOLE PINE CONTAINING A GOOD MANY CUBIC FEET OF DOWNED MATERIAL RESULTING FROM A WIDESPREAD OUTBREAK OF THE MOUNTAIN PINE BEETLE IN THE '30'S AND '40'S.) INSECT,FUEL/BIOMASS ACCUMULATION,FIRE EXCLUSION,FIRE BEHAVIOR,MORTALITY,GENERAL FIRE MANAGEMENT

288. 03 145 WHAT IS THE EFFECT OF VARYING INTENSITIES OF GROUND FIRES ON INSECTS AND OTHER ARTHROPODS INHABITING THE LITTER, DUFF AND SOIL IN DIFFERENT SOIL TYPES, FOREST TYPES, SLOPES ETC.? FIRE INTENSITY,GROUND FIRE,ARTHROPODS,LITTER,SOIL

289. 03 146 DO FIRE-ALLELOPATHIC RELATIONSHIPS EXIST IN NORTHERN ROCKY MOUNTAIN PONDEROSA PINE STANDS? ALLELOPATHY,EXPERIMENT ORIENTED QUESTION

290. 03 146 IS FIRE PERIODICITY IN FACT GOVERNED, TO A LARGE EXTENT, BY THE OCCURRENCE AND TIMING OF INSECT ATTACKS, DISEASE OUTBREAKS, WINDSTORMS, AND PREVIOUS FIRES? FIRE FREQUENCY,INSECT,DISEASE,WINDTHROW

291. 03 146 WHAT IS THE QUANTITATIVE RELATIONSHIP BETWEEN FIRE (OR FIRE EXCLUSION) AND THE ACCUMULATION OF DEAD ORGANIC MATTER ON THE FOREST FLOOR OF NORTHERN ROCKY MOUNTAIN CONIFEROUS FORESTS? HOW DOES THIS RELATIONSHIP VARY (BY HABITAT TYPE, ETC.)? FIRE FREQUENCY,FUEL/BIOMASS ACCUMULATION,FUEL REDUCTION

292. 03 147 CAN WE DEVELOP A LOGICAL GENERIC CLASSIFICATION, OR NOMENCLATURE, OF FIRE EFFECTS, BASED ON "MANAGEMENT" OR ECOLOGICAL OBJECTIVES? FOR EXAMPLE, "LIMITED FREE BURNING" SHOULD FIT INTO SOME CLASSIFICATION BY ECOLOGICAL OBJECTIVES, SUCH AS WILDERNESS MANAGEMENT, WHOSE DESIRED CHARACTERISTIC COULD BE QUITE DIFFERENT FROM "LIMITED FREE BURNING" FOR HAZARD REDUCTION IN TIMBER PRODUCTION. IN LATTER CASES, LIMITING TREE MORTALITY MAY BE THE MOST IMPORTANT CONSIDERATION, WHILE CONTAINMENT WITHIN THE MANAGEMENT UNIT MAY BE THE MAIN CONSIDERATION IN WILDERNESS MANAGEMENT. EXPERIMENT ORIENTED QUESTION

293. 03 147 HOW CAN WE ISOLATE LONG-TERM FIRE EFFECTS ON AN ECOSYSTEM FROM SHORT-TERM FACTORS AFFECTING SYSTEMS, SUCH AS AIR POLLUTION, BOUNDARY ENCROACHMENT TO WILDERNESS, AND SO FORTH? GENERAL FIRE MANAGEMENT,TIMING

294. 03 147 WHAT ARE BOUNDARY CONDITIONS (MAXIMUM AND MINIMUM VALUES FOR VARIOUS FIRE ATTRIBUTES) WHEREIN FIRE CAN CAUSE IRREVERSIBLE ECOLOGICAL CHANGES BY ALTERING ECOLOGIC, MICRO-METEOROLOGIC, AND OTHER FACTORS? GENERAL FIRE MANAGEMENT,FIRE BEHAVIOR

295. 03 148 DOES MAINTAINING AN AREA IN LOW LIFE-FORM VEGETATION AT LOW ELEVATION (2500-4000 FEET, NORTHERN IDAHO) AFFECT THE TIMING OF SPRING RUNOFF SIGNIFICANTLY? HYDROLOGY,TIMING,SUCCESSION,SHRUBLAND

296. 03 148 WHAT ARE PREDICTED (SIMULATED) LONG TERM EFFECTS ON SOIL FERTILITY OF MAINTAINING AN AREA, THAT NORMALLY SUCCEEDS TO TREE VEGETATION, IN A LOWER LIFE-FORM, NAMELY SHRUBS AND HERBACEOUS VEGETATION? FIRE FREQUENCY,SUCCESSION,SHRUB UNDERSTORY,NUTRIENTS

297. 03 148 WHAT ARE THE SPECIFIC ON-SITE SHORT TERM EFFECTS OF BURNING BRUSHFIELDS ON SOIL MOVEMENTS IN QUANTITATIVE TERMS? SHRUBLAND,SOIL EROSION

298. 03 149 THE NATURAL HISTORY OF THE NORTHERN ROCKIES SUGGESTS THAT SOME INSECT AND DISEASE PESTS HAVE BEEN STRONGLY INFLUENCED BY WILDFIRE. HAS THE CONTROL OF ANY INSECT OR DISEASE PESTS BY WILDFIRE PRECLUDED THE DEVELOPMENT OF STRONG GENETIC RESISTANCE MECHANISMS IN HOST SPECIES? INSECT,DISEASE,GENETIC RESPONSE

299. 03 149 OBSERVATION OF THE PATTERN OF LIVE TREES SURVIVING MAJOR WILDFIRES SUGGESTS A POPULATION STRUCTURE IDEAL FOR GENETIC DRIFT. TO WHAT EXTENT HAS GENETIC DRIFT PLAYED A MORE SIGNIFICANT EVOLUTIONARY ROLE IN THE NORTHERN ROCKY MOUNTAINS THAN IN OTHER NORTH TEMPERATE REGIONS? ARE NONADAPTIVE TRAITS MORE PREVALENT IN NORTHERN ROCKY MOUNTAIN CONIFERS THAN IN CONIFERS OF OTHER NORTH TEMPERATE REGIONS? GENETIC RESPONSE,POPULATION

300. 03 149 THERE IS EVIDENCE IN JACK PINE AND LODGEPOLE PINE, AND CERTAIN OTHER SEROTINOUS CONE PINES, THAT CONE SEROTINY IS CONTROLLED BY A SINGLE ADDITIVE-EFFECT GENE PAIR. HAS THIS BEEN CONFIRMED YET IN LODGEPOLE PINE? IF IT IS TRUE, WHAT ARE THE IMPLICATIONS FOR THE LODGEPOLE PINE MANAGER? GENETIC RESPONSE

301. 03 151 HOW LARGE MUST A FOREST FIRE BE TO ACTUALLY KILL ANY BIG GAME ANIMALS, AND WHAT PERCENTAGE OF SUCH POPULATIONS ARE KILLED (IF ANY) BY LARGE FIRES? AREA SIZE,GAME ANIMAL,MORTALITY

302. 03 151 HOW MUCH VARIATION IN POST-FIRE SUCCESSIONAL PATTERNS CAN BE ASSOCIATED WITH (A) SUPPRESSION ACTIVITY THAT LENGTHENS THE FIRE CYCLE AND PRESUMABLY INCREASES EVENTUAL BURNING SEVERITY, AND (B) PRESCRIBED BURNING UNDER LESS THAN IDEAL BURNING CONDITIONS, I.E., HIGH MOISTURE LEVELS AND WET SOILS? SUCCESSION,FIRE EXCLUSION,FUEL/BIOMASS ACCUMULATION,PRESCRIBED FIRE,CLIMATE,TIMING

303. 03 151 HOW MUCH VARIATION IN RESPROUTING RESPONSE FOLLOWING FIRE CAN BE EXPECTED AMONG THE COMMON SHRUB SPECIES OF THE BOREAL FOREST? WHAT MIGHT BE COMPARATIVE RESPROUTING RESPONSES OF PARTIALLY BURNED SHRUBS, AS COMPARED TO THOSE ON WHICH THE CROWN IS COMPLETELY KILLED? SHRUBLAND,REPRODUCTION,MORTALITY

304. 03 151 WHAT ARE THE IMMEDIATE EFFECTS OF FOREST FIRE ASH TRANSPORT IN STREAMS, HOW MUCH IS AQUATIC LIFE ACTUALLY AFFECTED, AND HOW LONG DOES THE EFFECT LAST? ASH,STREAM,INSECT,FISH,TIMING

305. 03 151 WHAT ARE THE RELATIONSHIPS AMONG BURNING SEVERITY, SOIL BACTERIAL POPULATIONS AND NITROGEN CYCLING IN FOREST SOILS? FIRE INTENSITY,MICROORGANISM,SOIL,NUTRIENTS

306. 03 154 ARE THERE POSITIVE CORRELATIONS BETWEEN THOSE NUTRIENTS IN UNIQUELY HIGH DEMAND BY FIRE ADAPTED PLANT SPECIES AND THOSE NUTRIENTS FOUND IN GREATEST QUANTITIES IN THE ASH FROM FOREST FIRES? NUTRIENTS,ASH,VEGETATION

307. 03 154 HOW DO SOIL ORGANISMS RESPOND TO FIRES OF VARIOUS INTENSITIES AND CONSEQUENT SOIL CHEMISTRY ALTERATIONS? SOIL,FIRE INTENSITY,NUTRIENTS

308. 03 154 IN THE ABSENCE OF FIRE, WHAT IS THE RATE OF TIE-UP OF BIOLOGICALLY IMPORTANT NUTRIENTS IN THE FORM OF DEAD, UNDECOMPOSED PLANT MATERIAL? WHAT IS THE RATE OF PRODUCTION OF DEAD MATERIAL OF PLANT ORIGIN AND THE RATE OF DECOMPOSITION (SANS FIRE), ESPECIALLY IN THOSE PLANT COMMUNITIES MOST IMPORTANT TO MAN IN TERMS OF PRODUCTIVITY? FIRE EXCLUSION,NUTRIENTS,FUEL/BIOMASS ACCUMULATION,DECOMPOSITION,PRODUCTIVITY

309. 03 154 WHAT ARE THE MECHANISMS AND DOMINANT VARIBLES WHICH DETERMINE THE OCCURRENCE AND LEVEL OF INSECT ATTACKS IN RESPONSE TO BURNING? WHAT TREES, AS AFFECTED BY FIRE, ARE MOST SUSCEPTIBLE TO ATTACK? IN PARTICULAR, HOW DOES SEASONAL TIMING OF THE FIRE INFLUENCE THE RATE AND LEVEL OF INFESTATION? EXPERIMENT ORIENTED QUESTION,INSECT,HERBIVORY,TIMING

310. 03 154 WHAT IS THE ADJUSTMENT IN ECOLOGICAL SUCCESSIONAL STATE, IN GIVEN PLANT COMMUNITIES, IN RESPONSE TO FIRES OF VARYING INTENSITY AND CHARACTER? IN PLANT COMMUNITIES, WHICH HAVE FOR EONS OF TIME BEEN MAINTAINED BY FIRE, WHAT IS THE PROBABLE BIOLOGICAL TERMINUS IF FIRE COULD BE INDEFINITELY OMITTED? SUCCESSION,FIRE INTENSITY,FIRE EXCLUSION

311. 03 154 WHAT IS THE RESPONSE OF VEGETATION (IE. SHIFTS IN SPECIES COMPOSITION, CHANGES IN PRODUCTION RATES WITHIN SPECIES, INJURY BY HEATING) TO BURNING AT VARIOUS FIRE INTENSITIES AND AT VARIOUS TIMES OF THE YEAR? HOW DO DIFFERENT PLANT COMMUNITIES RESPOND? SPECIES DIVERSITY,PRODUCTIVITY,HEAT EFFECTS,FIRE INTENSITY,TIMING

312. 03 154 WHAT KINDS AND AMOUNTS OF COMBUSTION PRODUCTS (GASES AND PARTICULATES) ARE PRODUCED AND CARRIED ALOFT IN A FIRE SMOKE COLUMN? HOW DO THESE VARY WITH THE KIND OF FUEL AVAILABLE AND ITS PHYSICAL STATE? NUTRIENTS,AIR POLLUTION,SPECIES DIVERSITY

313. 03 155 FOR A GIVEN ENVIRONMENT, HOW HAS THE NATURAL ROLE OF FIRE VARIED DUE TO OTHER FACTORS? FOR INSTANCE, IS THE FREQUENCY OF LIGHTNING OCCURRENCE BY GEOGRAPHIC AREAS ENOUGH DIFFERENT TO CONSTITUTE A MAJOR INDEPENDENT VARIBLE? ALSO, THE JUXTAPOSITION OF DIFFERENT ENVIRONMENTS WITH RESPECT TO EACH OTHER ADDS ANOTHER FACTOR OF VARIABILITY IN PREDICTING FIRE SUSCEPTIBILITY. MOSAIC,ZONATION,FLAMMABILITY,LIGHTNING-CAUSED FIRE,AREA SIZE

314. 03 155 HOW DOES FIRE INTENSITY VARY WITH: STAND AGE, COMPOSITION, DENSITY, TOPOGRAPHY, ASPECT, ENVIRONMENT, AND WEATHER? FIRE BEHAVIOR

315. 03 155 IS FUEL ACCUMULATION REALLY A CONTINUOUSLY INCREASING FUNCTION WITH TIME? HAS THIS HYPOTHESIS BEEN ADEQUATELY TESTED? I KNOW IT ACCUMULATES VERY RAPIDLY AT THE SUCCESSIONAL POINT WHERE THE SERAL STAND OF TIMBER BREAKS UP AND IS REPLACED BY TOLERANT SPECIES. HOWEVER, AFTER THIS POINT IN TIME DECOMPOSITION MAY ACCELERATE. FUEL/BIOMASS ACCUMULATION

316. 03 155 WHAT IS THE FIRE HISTORY OF OUR NATURAL FOREST STANDS IN RESPECT TO (A) DIFFERENT ENVIRONMENTS AND (B) DIFFERENT GEOGRAPHIC AREAS? WHAT ARE THE EXPECTED FREQUENCIES AND ACCOMPANYING INTENSITIES OF FIRES IN VARIOUS HABITAT TYPES? WHAT IS THE ROLE OF FIRES IN PP/BUNCHGRASS SAVANNAHS IN CONTRAST TO THE ROLE OF FIRE IN AF/MENZIESIA OR WRC/PACHISTIMA HABITATS? FIRE FREQUENCY,FIRE INTENSITY

317. 03 155 WHAT IS THE PROBABILITY AND PREDICTED INTENSITY OF A FIRE AT A GIVEN POINT IN TIME FOR A SPECIFIC ENVIRONMENT? I THINK WE NEED TO BEGIN DEVELOPING MODELS (HYPOTHESIS TO BE TESTED) THAT ARE ENVIRONMENT SPECIFIC AND TIME DEPENDENT TO EXPRESS A MAJOR PORTION OF THE VARIABILITY OF THE ROLE OF FIRE IN CONIFEROUS FORESTS. FIRE INTENSITY

318. 03 156 WHAT ARE THE SHORT AND LONG-TERM EFFECTS OF FIRES OF DIFFERENT INTENSITIES (INCLUDING NO FIRE) ON THE MICROFLORA AND MICROFAUNA OF THE FOREST FLOOR (INCLUDING DUFF AND FERMENTATION LAYERS AS WELL AS MINERAL SOIL) ON DIFFERENT ECOLOGICAL HABITAT TYPES? THIS SHOULD INCLUDE THOSE ORGANISMS GENERALLY REGARDED BENEFICIAL, AS WELL AS THOSE PATHOGENS FELT TO BE PROBLEMS FOR FOREST MANAGEMENT. FIRE FREQUENCY,FIRE INTENSITY,MICROORGANISM,LITTER,SOIL

319. 03 158 FROM A PLANT ECOLOGY AND FOREST SUCCESSION STANDPOINT, AN IMPORTANT ASPECT OF UNDERSTANDING THE ECOLOGICAL EFFECTS OF FIRE LIES IN THE AREA OF ADAPTATIONS TO SURVIVE FIRE. KNOWLEDGE OF THE MECHANISMS AND/OR STRATAGEM EMPLOYED BY AT LEAST THE "ECOLOGICALLY IMPORTANT" SPECIES OF POST-FIRE FOREST COMMUNITIES WOULD GIVE AN INSIGHT TO THEIR INITIATION AND PROVIDE THE KEY FOR PREDICTING THEIR COMPOSITION. (1.) WHAT PHYSICAL FORM (MORPHOLOGIC) DOES THE FIRE SURVIVAL ADAPTATION TAKE? (2.) WHERE IS THE MORPHOLOGICAL FEATURE LOCATED WITH RESPECT TO THE GROUND AND WHAT IS THE EFFECT OF FIRE INTENSITY? (3.) FOR DISPERSAL ADAPTATIONS WHAT ARE THE TIME WINDOW LIMITATIONS? GENETIC RESPONSE,FIRE FREQUENCY

320. 03 234 WHAT IS THE PROGRESSION OF USE BY MAMMALS AND BIRDS AFTER A MAJOR BURN HAS OCCURRED? ANIMALS,BIRD,SUCCESSION

321. 03 234 WHAT IS THE RECOVERY RATE OF RIPARIAN VEGETATION ALONG TROUT STREAMS AFTER FIRE? TIMING,STREAM,VEGETATION

322. 03 239 HOW DOES FIRE AND/OR FIRE EXCLUSION ALTER THE QUANTITY AND QUALITY OF STREAMFLOW REGIMENS AND AQUATIC INVERTEBRATES SO VITAL IN THE FISH FOOD WEB? FIRE EXCLUSION,HYDROLOGY,STREAM,FISH

323. 03 296 WHAT ARE THE QUANTITATIVE CHARACTERISTICS OF TIME, AREA, TOPOGRAPHIC, AND CLIMATIC DIMENSIONS RELATIVE TO THE HISTORIC INFLUENCE ON OCCURRENCE OF WILDFIRE IN CONIFEROUS FOREST SYSTEMS? FIRE HISTORY

324. 03 373 PERHAPS ONE OF THE GREATEST NEEDS TO PERSUE RESEARCH IN FIRE ECOLOGY IS THE LOCATION OF A NUMBER OF EXPERIMENTAL PLOTS REPRESENTATIVE OF SPECIFIC HABITAT TYPES THAT HAVE A WELL DOCUMENTED FIRE HISTORY AND VARY IN FREQUENCY AND INTENSITY OF THOSE FIRES. THESE SHOULD INCLUDE EXTREMES OF HIGH FREQUENCY AND COMPLETE FIRE EXCLUSION IN AS FAR AS POSSIBLE. MY RESEARCH INTERESTS WOULD INCLUDE (1) THE EFFECT OF FIRE HISTORY ON THE GEOGRAPHICAL LOCATION OF DISEASES (OR LACK THEREOF) AND THE EFFECTS OF THESE DISEASES ON SUBSEQUENT SITE PRODUCTIVITY AND SUCCESSIONAL PATTERNS AND (2) THE EFFECT OF FIRE HISTORY ON POPULATIONS OF BENEFICIAL MICROORGANISMS (INCLUDING DECAY FUNGI, MYCORRHIZAL FUNGI, AND NITROGEN FIXING MICROORGANISMS) AS THEY AFFECT SITE PRODUCTIVITY AND SUCCESSIONAL DEVELOPMENT. POPULATIONS OF SOIL MICROORGANISMS AS AFFECTED BY FIRE AND VEGETATIONAL HISTORY MAY PLAY A MORE IMPORTANT ROLE IN SUCCESSIONAL HISTORY AND SITE PRODUCTIVITY THAN HAS BEEN ASCRIBED TO THEM TO DATE. FIRE HISTORY,DISEASE,VEGETATION,PRODUCTIVITY,SUCCESSION,MICROORGANISM,NUTRIENTS

325. 03 400 IF WILDFIRE IS A KEY IN THE DEVELOPMENT OF VEGETATIVE PATTERNS IN EASTERN MONTANA PONDEROSA PINE FORESTS, WHAT SUBSTITUTES ARE AVAILABLE IF IT IS DECIDED TO RETAIN THESE PATTERNS? OR UNDER WHAT CONDITIONS COULD WE USE WILDFIRE? FIRE EXCLUSION,MANIPULATION COMPARISON,MOSAIC,FIRE EFFECTS

326. 03 429 WHAT AFFECT DOES SAGEBRUSH CONTROL BY FIRE IN CONIFEROUS FOREST MEADOWS HAVE ON NON-GAME SPECIES, I.E. SPARROWS, RODENTS, ETC.? SHRUBLAND,SMALL MAMMAL,BIRD

327. 03 429 WHAT IS THE EFFECT OF DIFFERENT DEGREES OF DUFF CONSUMPTION BY FIRE AS SEEN IN THE CHANGES IN: SOIL NUTRIENT QUANTITIES REMAINING, MICROBIAL POPULATION RESPONSE, SOIL WATER INFILTRATION RATES, MOISTURE HOLDING CAPACITY, AND SUBSEQUENT REGENERATION SUCCESS OF LODGEPOLE PINE, PONDEROSA PINE, DOUGLAS FIR, ALPINE FIR, AND SAGEBRUSH? FUEL REDUCTION,NUTRIENTS,MICROORGANISM,SOIL-WATER RELATIONS,REPRODUCTION

328. 03 429 WHAT IS THE RELATION BETWEEN FIRE INTENSITY, FUEL LOADING, FUEL SPECIES, AND FUEL CONSUMPTION AND HEATING AT VARIOUS DEPTHS IN UNCONSUMED DUFF LAYER? FIRE INTENSITY,FIRE BEHAVIOR

329. 03 429 WHAT SEASON OR MONTH WILL GIVE THE BEST RESULTS FOR NUTRIENT CYCLING FROM BROADCAST BURNING OF LOGGING SLASH IN LODGEPOLE PINE BOTH ON NORTH AND SOUTH FACING SLOPES, EAST OF THE CONTINENTAL DIVIDE IN MONTANA? FUEL REDUCTION,NUTRIENTS,TIMING,TOPOGRAPHY

330. 03 429 WHEN DOZER SCARIFYING, PILING AND BURNING IN LODGEPOLE PINE, IS THERE ONE RANGE OF CLEAN-UP PERCENTAGES WHICH GIVE BETTER VEGETATIONAL REPRODUCTION RESULTS THAN ANOTHER? E.G. WOULD THE LEAVING OF APPROX. 40 TO 50% OF THE SLASH GIVE BETTER RESULTS THAN LEAVING ONLY 20 TO 30%? FUEL REDUCTION,FUEL REDUCTION,REPRODUCTION,VEGETATION,LITTER

331. 03 430 IN THE INTERMOUNTAIN WEST, WHAT INTERVAL OF PRESCRIBED FIRE IS BEST TO KEEP AREAS IN SERAL BRUSH SPECIES ALONG WITH ADEQUATE ESCAPE COVER? HABITAT TYPES INVOLVED ARE: GRAND FIR-QUEEN BEADLILLY, DOUGLAS FIR-NINEBARK, DOUGLAS FIR-TWINFLOWER, PONDEROSA PINE-BITTERBRUSH, AND DOUGLAS FIR-SNOWBERRY. SHRUB UNDERSTORY,CONIFEROUS FOREST,WILDLIFE,PRESCRIBED FIRE,COMMUNITY

332. 03 433 ARE INTRODUCED GRASS SPECIES MORE SUSCEPTIBLE TO KILLING BY FIRE THAN NATIVE GRASSES? FIRE EFFECTS,GRASSLAND,MORTALITY

333. 03 433 WOULD PRESCRIBED BURNING OF OVERGRAZED MEADOWS AND NATURAL GRASS OPENINGS FAVOR QUICKER RESPONSE AND RECOVERY OF DESIRABLE GRASSES AND FORBS IF LIVESTOCK USE IS DEFERRED FOLLOWING BURNING? WHAT, IF ANY, WOULD BE THE BENEFITS OF SUCH PRESCRIBED BURNING TO BIG GAME WILDLIFE HABITAT? PRESCRIBED FIRE,HERBAGE UNDERSTORY,GRASSLAND,HERBIVORY,DOMESTIC LIVESTOCK,FIRE EFFECTS,WILDLIFE,GAME ANIMAL

334. 03 434 AS OUR FORESTS BECOME MORE AND MORE VALUABLE TO THIS AND FUTURE GENERATIONS, HOW CAN WE ACHIEVE THE RECOGNITION NEEDED OF FUEL MANAGEMENT AND THE NEED TO DISPOSE OF FUEL AS THE ONLY POSITIVE MEANS OF FIRE PREVENTION? PUBLIC REACTION

335. 03 434 WE NEED A MEANS OF PRESCRIBING CONDITIONS NECESSARY TO ACCOMPLISH A PARTICULAR OBJECTIVE IN USING FIRE AS A MEANS OF FUEL REDUCTION. IT MIGHT BE POSSIBLE TO PROGRAM A COMPUTER WITH KNOWN ENTITIES SUCH AS FUEL VOLUME, AGE OF SLASH DISTRIBUTION, HABITAT TYPE, MOISTURE CONTENT, WEATHER CONDITIONS, ASPECT, SLOPE, ETC. IF THIS CAPABILITY WERE AVAILABLE, IT COULD BE APPLIED TO NATURAL ACCUMULATIONS AS WELL AS LOGGING SLASH. FUEL REDUCTION,FIRE BEHAVIOR,PRESCRIBED FIRE

336. 03 435 WHAT IS THE EFFECT OF THUNDERSTORM PRECIPITATION INTENSITY AND DURATION ON LIGHTNING FREQUENCY AND UPON IGNITION PROBABILITY IN LODGEPOLE PINE FORESTS? LIGHTNING-CAUSED FIRE,FIRE FREQUENCY,FLAMMABILITY

337. 03 436 ARE EAGLE AND HAWK NESTING SITES AFFECTED BY SLASH BURNING IN THE FALL? BIRD,SMOKE EFFECTS,FIRE EFFECTS,PRESCRIBED FIRE,TIMING,COMMUNITY

338. 03 436 ARE SOME TREE SPECIES PHYSIOLOGICALLY DAMAGED BY SMOKE? SMOKE EFFECTS,CROWN

339. 03 436 WHAT EFFECT DOES THE ASH AND CHARRED MATERIAL HAVE ON THE FISHERIES IN A PARTICULAR STREAM SO FAR AS THE OXYGEN LEVEL IS CONCERNED? FISH,ASH,CHARCOAL,STREAM,FIRE EFFECTS

340. 03 436 WHAT EFFECTS DO SPRING BURNS HAVE ON INCREASED EROSION POTENTIAL, MOISTURE RETENTION AND PRODUCTIVITY, AS COMPARED WITH FALL BURNS? PRESCRIBED FIRE,TIMING,SOIL-WATER RELATIONS,SOIL EROSION

341. 03 437 WHAT MIGHT BE THE EFFECT OF BROADCAST BURNING IN SEROTINOUS LODGEPOLE PINE CLEARCUTS, COMPARED WITH DOZER PILING, BURNING AND SCARIFICATION, AS OBSERVED IN QUANTITY OF REPRODUCTION? PRESCRIBED FIRE,REPRODUCTION,SEED,CONIFEROUS FOREST,HUMAN DISTURBANCE,MANIPULATION COMPARISON

342. 03 438 ARE THERE QUANTITATIVE MEASURES OF DETERMINING STAGES OF ECOLOGICAL FIRE CYCLES AND THE EFFECTS OF KEEPING FIRE FROM PLANT COMMUNITIES? SUCCESSION,FIRE FREQUENCY,FIRE EXCLUSION,FIRE EFFECTS

343. 03 438 WHAT VARIOUS COMBINATIONS OF FUEL CONDITIONS AND WEATHER WILL ALLOW FIRE UNDER STANDING PONDEROSA PINE WITH THE EXPECTATION OF KILLING VERY FEW TREES IN EXCESS OF TWO INCHES D.B.H.? PRESCRIBED FIRE,CLIMATE,FIRE INTENSITY,CONIFEROUS FOREST,STEM,ORGAN,MORTALITY,FIRE EFFECTS

344. 03 439 UNDER WHAT CONDITIONS WILL A SOUTH-FACING SLOPE PRESENT NATURAL REGENERATION PROBLEMS AFTER A CROWN BURN IN PONDEROSA PINE? CROWN BURN,REPRODUCTION,TOPOGRAPHY,VEGETATION

345. 03 439 WHAT IS THE EFFECT OF DECREASING THE FIRE FREQUENCY AT VARIOUS INTENSITIES, AS SEEN IN THE RATE OF FOREST ENCROACHMENT ON RANGE LANDS? FIRE FREQUENCY,FIRE EXCLUSION,ECOTONE,SUCCESSION,FIRE INTENSITY,GRASSLAND,VEGETATION

346. 03 439 WHAT IS THE EFFECT OF INCREASING PERCENT OF CROWN SCORCHING OF PONDEROSA PINE DURING A FIRE, AS SEEN IN THE PROBABILITY OF TOTAL TREE MORTALITY FOLLOWING THE FIRE? HEAT EFFECTS,MORTALITY,ORGANISM,VEGETATION

347. 03 440 IF FIRE WERE TO CONSUME LARGE FORESTED AREAS OF EASTERN MONTANA PONDEROSA PINE, WHAT CAN WE EXPECT FROM THE INCREASE IN GROUND WATER (ANNUAL PRECIPITATION THAT NORMALLY WOULD HAVE BEEN TRANSPIRED BY THE TREES, BUT WOULD NOW PERCOLATE DOWN)? COULD SALINE SEEPS DEVELOP? WOULD FLOWS INCREASE AT SPRINGS? SOIL-WATER RELATIONS,FIRE EFFECTS,AREA SIZE,NUTRIENTS,ELEMENTS,COMPOUNDS,CONIFEROUS FOREST

348. 03 440 IN EASTERN MONTANA PONDEROSA PINE, IS THE GENERAL DENDRITIC PATTERN OF OUR FORESTED LANDS BASED MOSTLY ON A SOIL-MOISTURE RELATIONSHIP OR HAS WILDFIRE SOMEHOW INFLUENCED THIS PATTERN? IF FIRE HAS CONTRIBUTED TO THIS PATTERN, IN WHAT AREAS (OR AREA CHARACTERISTICS) CAN WE EXPECT PONDEROSA PINE ENCROACHMENT? HOW IS FIRE PROTECTION INFLUENCING THE VEGETATIVE PATTERNS IN THIS COUNTRY? FIRE EFFECTS,MOSAIC,ECOTONE,AREA SIZE,CONIFEROUS FOREST,DISPERSION,SOIL-WATER RELATIONS

349. 03 444 ARE THERE PRACTICAL GUIDELINES EXISTANT FOR PROGRESSIVE UNDERSTORY BURNING, THAT IS, REDUCING HEAVY FUEL LOADS THROUGH A SERIES OF PRESCRIBED FIRES AT A GIVEN LOCATION? PRESCRIBED FIRE,GENERAL FIRE MANAGEMENT,FIRE INTENSITY

350. 03 447 WHAT IS THE RATE OF HYDROLOGIC RECOVERY ON BROADCAST BURN AREAS AS COMPARED TO THE RATE IN SIMILAR STANDS RECEIVING MECHANICAL SITE PREPARATION? HUMAN DISTURBANCE,MANIPULATION COMPARISON,WATERSHED,SOIL-WATER RELATIONS,PRESCRIBED FIRE

351. 03 653 CUTTHROAT TROUT POPULATIONS STILL EXIST IN SEVERAL MOUNTAIN HEADWATER STREAMS. WHAT ECOLOGICAL EFFECTS DO YOU FEEL CAN BE RELATED TO THIS SPECIES CONCERNING FIRE? STREAM,FISH,FIRE EFFECTS,POPULATION

352. 03 653 TO WHAT DEGREE IS SILTATION INCREASED IN STREAMS IN BURNED AREAS, PARTICULARLY HEADWATER STREAMS? FIRE EFFECTS,STREAM,SOIL EROSION,ECOSYSTEM

353. 03 653 WHAT ARE THE EFFECTS OF NEW BURNS ON AQUATIC LIFE AS OBSERVED IN STREAM TEMPERATURE? STREAM,FIRE EFFECTS,FISH,INSECT

354. 03 718 IN THE AREA NORTH OF WHITEHALL, MONTANA, EXTENSIVE DOUGLAS FIR STANDS GROW IN MARGINAL SOIL SITES WITH ONLY 12-14 INCHES OF PRECIPITATION. VIGOR IS VERY LOW IN THE FIR. ENCROACHMENT OF FIR INTO NATURAL OPENINGS IS VERY EXTENSIVE. THIS IS A CHRONIC WILDFIRE AREA. BOTH STOCK GRAZING AND PARTICULARLY FIRE PROTECTION, INFLUENCE FIR ENCROACHMENT. WHAT IS THE ROLE OF WILDFIRE IN THIS VEGETATIVE ASPECT, IN THE MAINTENANCE OF MORE EXTENSIVE GRASSLAND TYPES WHICH ARE INTERSPERSED WITH MORE FAVORABLE TIMBER SITES? HOW HAS FIRE PROTECTION INFLUENCED ELK FORAGE AND DEER COVER? IS WOODY FUEL NOW CONCENTRATED ENOUGH THAT PRESCRIBED BURNING WOULD BE HOT ENOUGH TO IMPART HYDROPHOBIC PROPERTIES TO THE SOIL? SPRUCE BUDWORM INFESTATION IS EXTREMELY HIGH ON FIR ENCROACHMENT SITES. IS FIRE PROTECTION ENCOURAGING ESTABLISHMENT OF LOW VIGOR FIR STANDS WHICH ARE MORE SUSCEPTIBLE TO BUDWORM INFESTATION AND FIRE HAZARD? IS FIRE PROTECTION, AND THE ASSUMED INCREASE IN ENCROACHMENT AND BUDWORM INFESTATION BUILDING A GREATER FIRE HAZARD WHICH MAY THREATEN LARGER AREAS? WOULD WILDFIRES MAINTAIN FIRE CLIMAX VEGETATIVE TYPES WITH STABLE WATERSHEDS, HIGH VIGOR TIMBERED SITES WITH LOWER INTENSITY BUDWORM INFESTATIONS, AND SUITABLE ELK WINTER RANGES? SUCCESSION,GRASSLAND,DISPERSION,FIRE EXCLUSION,GAME ANIMAL,FUEL/BIOMASS ACCUMULATION,FIRE INTENSITY,SOIL-WATER RELATIONS,INSECT,PRODUCTIVITY,AREA SIZE

355. 03 718 IN YOUR OPINION, IS THERE ANY SIGNIFICANT DIFFERENCE BETWEEN EFFECTS OF PRESCRIBED BURNING FOR INSECT CONTROL, SITE PREPARATION, ETC., AND THE EFFECTS OF WILDLAND NATURAL FIRE WITH REGARD TO THESE SAME RESPONSES? MANIPULATION COMPARISON,PRESCRIBED FIRE,INSECT,REPRODUCTION

356. 03 718 WHAT IS THE TIME DIFFERENTIAL IN THE REDUCTION OF CHARRED LOGGING WASTE AS COMPARED TO UNTREATED WASTE? FUEL REDUCTION,DECOMPOSITION,CHARCOAL,MANIPULATION COMPARISON

357. 03 718 WHAT IS THE TOTAL EFFECT OF FIRE ON AVAILABLE NUTRIENTS FOR TREE GROWTH OVER A ROTATION PERIOD? NUTRIENTS,FUEL/BIOMASS ACCUMULATION

358. 03 719 DOES FINE ASH DECREASE SOIL POROSITY AND INCREASE RUN OFF? IF SO, FOR HOW LONG? SOIL-WATER RELATIONS,ASH,SOIL

359. 03 719 TO WHAT DEGREE CAN CONTROLLED BURNING BE USED TO CONTROL SPRUCE BUD WORM OR OTHER PESTS? INSECT,PRESCRIBED FIRE,FIRE EFFECTS,COMMUNITY,CONIFEROUS FOREST

360. 03 719 TO WHAT DEGREE CAN POLE SIZE TIMBER BE SCORCHED BY FIRE BEFORE IT DIES? IS THERE A CAMBIUM TEST WHICH WOULD AID THE FORESTER IN PLANNING POST-FIRE FOREST REHABILITATION? ORGAN,FIRE EFFECTS,STEM,MORTALITY,HEAT EFFECTS

361. 03 719 WHAT IS DEGREE OF CHANGE IN SNOW PACK OR RUN OFF CHARACTERISTICS ON VARIOUS TYPES OF BURNED OVER BUT STANDING VEGETAL COVER? SNOW,MICROCLIMATE,ASH,CHARCOAL,SOIL-WATER RELATIONS,SNAG

362. 03 743 IS THE FUEL ACCRETION PROCESS IN DRY FOREST SITES ONE OF DIMINISHING ACCRETION WITH TIME OR UNLIMITED ACCRETION WHEN FIRE HAS BEEN EXCLUDED? FUEL/BIOMASS ACCUMULATION,FIRE EXCLUSION,CLIMATE,CONIFEROUS FOREST

363. 03 743 THE USE OF FIRE IN STANDING PONDEROSA PINE IS LIMITED BECAUSE OF POSSIBLE SUBSEQUENT BARK BEETLE ATTACKS. THIS AREA OF STUDY IS VIRTUALLY DEVOID OF GOOD INFORMATION. SUCH INFORMATION WOULD ASSIST IN DETERMINING BURNING SCHEDULES, ACCEPTABLE FIRE INTENSITIES (IN RELATION TO LOCAL BEETLE POPULATIONS AND TIME OF YEAR OF BURN) AND GENERAL REALIZATION OF UNDERSTORY FIRE LIMITATIONS OR POTENTIAL. FIRE EFFECTS,INSECT,STEM,PRESCRIBED FIRE,TIMING,FIRE INTENSITY,CONIFEROUS FOREST,COMMUNITY

364. 03 744 WE HAVE CERTAIN AREAS IN LODGEPOLE-SPRUCE TYPE THAT WERE BROADCAST BURNED AFTER LOGGING THAT HAVE NOT REGENERATED AFTER 3-4 YEARS. CROWN BURNS IN THE SAME VICINITY HAVE REGENERATED VERY QUICKLY. DOES INTENSITY OF BURN DETERMINE REGENERATION POTENTIAL OF LODGEPOLE? CAN SOIL BE "STERILIZED" FOR A PERIOD WITH A VERY HOT FIRE? PRESCRIBED FIRE,FIRE EFFECTS,CROWN BURN,REPRODUCTION,SOIL,NUTRIENTS,FIRE INTENSITY,COMMUNITY

365. 03 745 HOW MUCH FIRE (HEAT) CAN A TREE TAKE BEFORE IT BECOMES WEAKENED TO THE POINT THAT BARK BEETLES ARE ATTRACTED TO IT? OTHER INSECTS AND DISEASE? HEAT EFFECTS,MORTALITY,INSECT,DISEASE,STEM,FIRE EFFECTS,ORGANISM

366. 03 745 HOW WOULD GREEN BELTS (UNTHINNED AREAS) AROUND OR THROUGH THINNING AREAS AFFECT FIRE SPREAD? HUMAN DISTURBANCE,MANIPULATION COMPARISON,PRESCRIBED FIRE,FIRE EXCLUSION

367. 03 745 SHOULD RESEEDING (GRASS, BROWSE SP. OR TREE SP.) BE IMPLEMENTED IMMEDIATELY AFTER A FIRE? TIMING,REPRODUCTION,SOIL EROSION,FIRE EFFECTS,MANIPULATION COMPARISON

368. 03 745 UNDER WHAT CONDITION MAY BROADCAST BURNING BE FEASIBLE FOR HAZARD REDUCTION IN THINNED STANDS? PRESCRIBED FIRE,FLAMMABILITY,FUEL REDUCTION

369. 03 745 WHAT IS THE ADVISABILITY OF FERTILIZING A SEVERLY BURNED AREA? HOW SEVERE A BURN WOULD BE DETRIMENTAL TO SOIL NUTRIENTS? SOIL,NUTRIENTS,FIRE INTENSITY,FIRE EFFECTS

370. 03 745 WHAT IS THE EFFECT OF FIRE EXCLUSION ON INSECT ACTIVITY? DISEASE SPREAD? FIRE EXCLUSION,INSECT,DISEASE

371. 03 745 WHAT KIND OF THINNING BLOCK LAYOUT WOULD TEND TO REDUCE THE CHANCE OF FIRE SPREAD IN PRECOMMERCIAL THINNING AREAS? HUMAN DISTURBANCE,FIRE INTENSITY,GENERAL FIRE MANAGEMENT,AREA SIZE

372. 03 745 WHAT PRACTICAL AND ECONOMICAL STEPS MIGHT BE TAKEN TO REDUCE HAZARD IN FRESH PRECOMMERCIAL THINNING SLASH? GENERAL FIRE MANAGEMENT,HUMAN DISTURBANCE,FLAMMABILITY,ECONOMIC EFFECTS

373. 03 745 WILL FIRE IN A THINNED STAND TEND TO STAY ON THE GROUND AS OPPOSED TO CROWNING? WHAT ARE THE EFFECTS OF VARIOUS SPACING? WHAT SPACING INHIBITS SPREAD OF FIRE? HUMAN DISTURBANCE,GROUND FIRE,CROWN BURN

374. 03 745 WILL RAIN ON THE ASH IN A BURN CAUSE A LAYER IMPERMEABLE TO SEEDS TO BE FORMED? IF SO, HOW LONG WILL THIS LAYER LAST? (THIS CONDITION IS REPORTED TO OCCUR IN THE SOUTHWEST.) MICROCLIMATE,ASH,SOIL-WATER RELATIONS,FIRE EFFECTS,SEED,REPRODUCTION

375. 04 108 CAN NATIVE HERBIVORE (BISON, ELK, DEER, ANTELOPE, PRAIRIE DOGS) DISTRIBUTION BE MANIPULATED BY PERIODIC PRESCRIBED BURNING IN PONDEROSA PINE GRASSLAND IN THE BLACK HILLS? GAME ANIMAL,DISPERSION,PRESCRIBED FIRE,HERBIVORY,GRASSLAND

376. 04 108 WHAT FIRE TEMPERATURES AND FLAME HEIGHTS ARE NECESSARY TO KILL VARIOUS SIZE PONDEROSA PINE SEEDLINGS AND SAPLINGS WHICH HAVE INVADED GRASSLANDS ADJACENT TO AND WITHIN THE BLACK HILLS? WHAT FREQUENCY OF PRESCRIBED BURNING IS REQUIRED TO PROHIBIT OR REDUCE INVASION OF PONDEROSA PINE INTO GRASSLANDS ADJACENT TO THE BLACK HILLS? FIRE INTENSITY,MORTALITY,REPRODUCTION,FIRE FREQUENCY,PRESCRIBED FIRE

377. 04 108 WHAT IS THE EFFECT OF BURNING, AT VARIOUS SEASONS, ON SOILS AND UNDERSTORY VEGETATION IN THE BLACK HILLS? (HYPOTHESIS: SLASH CAN BE BURNED MORE SAFELY AND WITH LESS DAMAGE TO SOILS AND VEGETATION DURING SPRING AND EARLY SUMMER MONTHS FOLLOWING PRECIPITATION THAN IN WINTER MONTHS.) TIMING,HERBAGE UNDERSTORY,SOIL,CLIMATE

378. 04 108 WHAT IS THE EFFECT OF SEASONAL BURNING ON FORAGE PRODUCTION AND SPECIES COMPOSITION IN GRASSLANDS ADJACENT TO AND WITHIN THE BLACK HILLS PONDEROSA PINE FOREST? (WHAT IS THE PROPER SEASON FOR PRESCRIBED BURNING IN THIS VEGETATION TYPE?)
GRASSLAND,PRODUCTIVITY,SPECIES DIVERSITY,PRESCRIBED FIRE

379. 04 159 CAN PRESCRIBED FIRE BE USED SAFELY AND EFFECTIVELY TO CONTROL STOCKING IN IMMATURE PINE STANDS?
AGE,PRESCRIBED FIRE,DENSITY,FUEL/BIOMASS ACCUMULATION

380. 04 159 IN FULLY-STOCKED PINE STANDS OF VARIOUS AGES AND SIZES, WHAT IS THE RELATION BETWEEN PRODUCTION AND DECOMPOSITION OF BIOMASS (HENCE, FUEL), IN TOTAL, AND BY MAJOR COMPONENTS? HAS FIRE EXCLUSION, IN FACT, MARKEDLY ALTERED THE FUEL ACCUMULATION REGIME? FIRE EXCLUSION,DENSITY,AGE ,SIZE CLASS,FUEL/BIOMASS ACCUMULATION,DECOMPOSITION,REPRODUCTION,MORTALITY

381. 04 159 IS IT POSSIBLE--AND SAFE--TO USE BROADCAST BURNING FOR FUEL AND HAZARD REDUCTION IN PRECOMMERCIALLY THINNED STANDS? PRESCRIBED FIRE,FUEL REDUCTION

382. 04 159 WHAT FACTUAL EVIDENCE EXISTS, OR CAN BE OBTAINED, TO SUPPORT THE POPULAR BELIEF THAT NON-CATASTROPHIC BURNS OCCURRED MORE OR LESS REGULARLY IN BLACK HILLS PINE STANDS IN PRE-SETTLEMENT TIMES? AND, FURTHER THAT THEIR EFFECTS WERE LARGELY BENEFICIAL IN TERMS OF REDUCED RISK OF CATASTROPHIC FIRES, NATURAL CONTROL OVER FOREST STOCKING, MORE FORAGE FOR GAME, AND INCREASED WATER PRODUCTION FROM FORESTED WATERSHEDS? GROUND FIRE,FIRE FREQUENCY,EXPERIMENT ORIENTED QUESTION,FUEL REDUCTION,FUEL/BIOMASS ACCUMULATION

383. 04 159 WHAT SPECIAL KIND OF BURNING ENVIRONMENT MUST PREVAIL TO FOSTER A NON-CATASTROPHIC, FUEL-REDUCTION-TYPE OF BURN IN STANDS OF VARIOUS CLASSES? HOW FREQUENTLY DO THESE SPECIAL BURNING CONDITIONS OCCUR? PRESCRIBED FIRE,FUEL REDUCTION

384. 04 161 COULD FIRE BE USED, TOGETHER WITH FOLLOWUP SEEDING OF HERBACEOUS AND/OR SHRUB SPECIES, AS BIOLOGICAL CONTROL OF TREE SPECIES THAT TEND TO REGENERATE TOO THICKLY UNDER CERTAIN CONDITIONS?
PLANTING,GRASSLAND,SHRUBLAND,COMPETITION,REPRODUCTION

385. 04 161 DO OLD BURNS (10 YEARS OR OLDER) IN WHICH TREES HAVE NOT REGENERATED TO A FULLY STOCKED STAND, CONTRIBUTE MORE RUNOFF AND SEDIMENT UNDER FLOOD PRODUCING PRECIPITATION, THAN OLD FOREST WITH VIRTUALLY UNDISTURBED FOREST FLOOR? DENSITY,HYDROLOGY,SOIL EROSION

386. 04 161 IS FIRE NECESSARY TO PROVIDE SUITABLE SITE CONDITION FOR ESTABLISHMENT AND VIGOROUS GROWTH OF CERTAIN TREE SPECIES--ALSO UNDERSTORY VEGETATION? IMPORTANT ELEMENTS OF WHICH SEEM TO REQUIRE NEAR MINERAL SOIL CONDITIONS FOR GERMINATION AND ESTABLISHMENT?
REPRODUCTION

387. 04 161 TO WHAT EXTENT DOES FIRE PLAY A ROLE IN SUCCESSION AND COMPOSITION OF FOREST STANDS? IS VIRTUAL EXCLUSION OF FIRE BY MODERN SUPPRESSION TECHNIQUES ALTERING BIOLOGICAL COMPOSITION OF FOREST ENVIRONMENT AND RESULTING IN UNDESIRABLE BUILDUP OF BIOMASS? FIRE EXCLUSION,SPECIES DIVERSITY,FUEL/BIOMASS ACCUMULATION,SUCCESSION

388. 04 161 TO WHAT EXTENT, AND UNDER WHAT CONDITIONS, ARE INFILTRATION AND PERCOLATION INHIBITED BY FORMATION OF HYDROPHOBIC SUBSTANCES DURING BURNS? SOIL-WATER RELATIONS

389. 04 449 CROWN FIRES ARE QUITE OFTEN A THREAT IN THE PONDEROSA PINE OF THE BLACK HILLS. EXTREME BURNING CONDITIONS MAY CAUSE CROWNING ANY TIME OF THE DAY OR NIGHT. BASED ON SLOPE, WHAT TREE SPACING WOULD ALLOW FULL STOCKING AND YET BE MOST DESIRABLE FOR SEPARATING TREE CROWNS TO PRECLUDE CROWN FIRE IGNITION? CROWN BURN,FIRE INTENSITY,AREA SIZE,TOPOGRAPHY,POPULATION

390. 04 449 HAS ANYONE CONSIDERED A CHEMICAL OR BIOLOGICAL TREATMENT OF PINE SLASH TO SPEED THE DECOMPOSITION AS A METHOD FOR REDUCTION OF FIRE HAZARD? DECOMPOSITION,COMPOUNDS,FUEL REDUCTION,CONIFEROUS FOREST,HUMAN DISTURBANCE

391. 04 449 IN BLACK HILLS PONDEROSA PINE,AT WHAT POINT DOES THE BURNING OF GROUND FUEL (DUFF) PASS THE POINT OF "CLEAN BURNING" AND BECOME DETRIMENTAL TO THE SOIL AND VEGETATION? WILL MUCH HEAT KILL THE ROOTS OF PLANTS AND TOO HOT A BURN PERMIT SOIL EROSION? HOW CAN WE MEASURE THE BURNING CONDITION THAT WILL PREVENT THIS? WE KNOW THAT THE FUEL VOLUME AND BURNING INDEX WILL DETERMINE THE INTENSITY ON THE SURFACE BUT WE NEED HELP TO DETERMINE THE UNDERGROUND EFFECT. WHAT CHANGES WILL SLOPE, ASPECT AND SOIL TYPE HAVE? DUFF,SOIL,HEAT EFFECTS,FIRE EFFECTS,TOPOGRAPHY,FIRE INTENSITY,ROOTS,SOIL EROSION,CONIFEROUS FOREST,ORGAN

392. 04 449 WE ARE CONSIDERING THE USE OF BROADCAST BURNING THROUGH THINNED PINE STANDS FOR FUEL REDUCTION. HOW MUCH IS REQUIRED TO KILL THE 2 TO 5 INCH PONDEROSA PINES? WILL CONTROLLED BURNING KILL OUT CERTAIN SPECIES OF GRASSES AND SHRUBS? PRESCRIBED FIRE,HEAT EFFECTS,STEM,CONIFEROUS FOREST,FUEL REDUCTION,SHRUB UNDERSTORY,HERBAGE UNDERSTORY

393. 04 659 FIRE SUPPRESSION IN BLACK HILLS PONDEROSA PINE OVER A PERIOD OF 70 PLUS YEARS HAS LED TO THE ESTABLISHMENT OF MANY "DOG HAIR" STANDS. IN MANY CASES, THESE STANDS HAVE BECOME SO DENSE THAT ALL OTHER PLANT SPECIES HAVE BEEN ELIMINATED. A) WHAT CHANGES HAVE THUS OCCURRED IN SOIL CHEMISTRY AND WHAT INFLUENCE HAVE THESE HAD ON THE PLANT COMMUNITY? B) WHAT INFLUENCE WILL PRESCRIBED FIRE HAVE ON SOIL CHEMISTRY AND THE PLANT COMMUNITY FOLLOWING PRE-COMMERCIAL THINNING? C) CAN PRE-SUPPRESSION FOREST CHARACTERISTICS BE RE-CREATED WITH THE USE OF PRESCRIBED FIRE? FIRE EFFECTS,SOIL,COMPETITION,FIRE EXCLUSION,PRESCRIBED FIRE,COMPOUNDS,HUMAN DISTURBANCE,CONIFEROUS FOREST

394. 04 833 ARE THERE ANY GUIDE LINES ESTABLISHED AS TO HOW OFTEN A STAND'S UNDERSTORY SHOULD BE BURNED BASED ON SPECIES AND TOTAL DRY WEIGHT ACCUMULATED ON THE FOREST FLOOR? GENERAL FIRE MANAGEMENT,FUEL/BIOMASS ACCUMULATION,PRESCRIBED FIRE,FIRE FREQUENCY,FIRE INTENSITY

395. 04 833 DOES A SURFACE FIRE OF MODERATE INTENSITY IN BLACK HILLS PONDEROSA PINE INCREASE THE POSSIBILITY OF A RESIDUAL STAND BEING ATTACKED BY BARK BEETLES? IF SO, HOW GREAT IS THIS INCREASE? INSECT,FIRE EFFECTS,GROUND FIRE,FIRE INTENSITY,STEM

396. 04 833 HOW GREAT IS THE INCREASE IN RUNOFF AFTER A PRESCRIBED BURN AS COMPARED TO AN UNBURNED STAND? SOIL-WATER RELATIONS,PRESCRIBED FIRE,MANIPULATION COMPARISON

397. 05 099 HOW DOES FIRE AFFECT THE MAJOR PROCESSES CONTROLLING MOVEMENT OF NUTRIENTS THROUGH A SINGLE ECOSYSTEM, AS CONTRASTED WITH A GROUP OF ADJACENT ECOSYSTEMS? IN OTHER WORDS, DOES FIRE MERELY CHANGE STRUCTURE AND ENVIRONMENT IN A MORE EXTREME WAY THAN CUTTING? DO DECOMPOSITION AND NUTRIENT INTERCHANGE AND UPTAKE, CHANGE IN RELATION TO CONCENTRATION OF IONS, REDUCTION IN SUBSTRATE, AND MORE EXTREME ENVIRONMENTS FOLLOWING FIRE, OR ARE THERE UNIQUE PROPERTIES OF FIRE (HIGH TEMPERATURES) THAT PRODUCE SPECIAL EFFECTS? CAN YOU DEVELOP A STRUCTURED MODEL FOR THE LUBRECHT WATERSHED, PREDICTING DIRECTION AND MAGNITUDE OF CHANGE IN NUTRIENT FLOW RATES AND COMPARTMENT LEVELS FOLLOWING INTENSE AND MODERATE FIRE? CAN YOU COUPLE YOUR KNOWLEDGE OF FIRE BEHAVIOR, AND HOW IT CHANGES THE ENVIRONMENT OF STANDS, WITH REED AND EMMINGHAM'S FOREST GROWTH AND SUCCESSION MODEL? NUTRIENTS,PRODUCTIVITY,SUCCESSION,MANIPULATION COMPARISON

398. 05 102 ARE EFFECTS OF FIRE ON MINERALIZATION OF TIED-UP NUTRIENTS REPLACED BY THE INCREASES OF WEATHERING, DUE TO EXPOSURE OF LITTER TO SUN, IN CLEARCUTTING? MANIPULATION COMPARISON,DECOMPOSITION,LITTER,NUTRIENTS,MICROCLIMATE

399. 05 102 HOW DOES THE IMPACT OF FIRE COMPARE WITH THAT OF OTHER DISTURBANCES: A) CLEARCUTTING B) SCARIFYING C) HERBICIDE TREATMENT: WITH RESPECT TO: A) PLANT COMPOSITION B) SUCCESSIONAL DYNAMICS C) MICROFLORA D) NUTRIENT RETENTION SYSTEMS E) WILDLIFE PALATABILITY OF VEGETATION AND ANIMAL POPULATION DYNAMICS? MANIPULATION COMPARISON,SPECIES DIVERSITY,VEGETATION,SUCCESSION,MICROORGANISM,NUTRIENTS, WILDLIFE

400. 05 102 TO WHAT EXTENT IS FIRE INVOLVED IN MAINTAINING SYSTEM PRODUCTIVITY WHERE NUTRIENT CAPITAL TENDS TO BE TIED UP IN LITTER? LITTER,NUTRIENTS,PRODUCTIVITY

401. 05 103 IF WE ASSUME THAT SOME WESTERN CONIFEROUS FORESTS HAVE EVOLVED WITH FIRE, HAVE THERE BEEN CHANGES IN ECOSYSTEM PROCESSES WITH THE CESSATION OF FIRE? I.E. HAS THE RATE OF MINERAL CYCLING BEEN ALTERED? IF SO, IN WHICH DIRECTION? FIRE EXCLUSION,NUTRIENTS

402. 05 103 WHAT ARE THE EFFECTS OF FIRE ON SECONDARY SUCCESSION? IS THE FREQUENCY, TIMING, OR INTENSITY OF THE FIRE MOST IMPORTANT ON 1) THE SUCCESSIONAL VECTOR AFTER THE BURN? 2) THE FIRST COVER TYPE TO ESTABLISH ON THE BURNED AREA? 3) THE RECOVERY TIME TO ORIGINAL STATE? SUCCESSION,TIMING,FIRE INTENSITY,FIRE FREQUENCY

403. 05 168 A. ARE THERE SERIOUS HARMFUL EFFECTS ASSOCIATED WITH EARLY SPRING BURNING IN THE STEEP NORTH-SLOPE DOUGLAS FIR-PHYSOCARPUS-PINEGRASS (FESCUE) CANYON HABITAT IN THE TRI-STATE UPLANDS? B. IF NOT, WHAT MIGHT BE THE PROPER FREQUENCY (TIME INTERVAL) FOR IMPROVING THESE HABITATS FOR LIVESTOCK GRAZING OR FOR BIG GAME USE? EXPERIMENT ORIENTED QUESTION,GAME ANIMAL,TIMING,PRESCRIBED FIRE

404. 05 168 A. DOES BROADCAST BURNING, AS A POST-CLEARCUT LOGGING SLASH TREATMENT, IN THE INTERIOR PACIFIC NORTHWEST TRUE FIR TYPE, ALTER THE PLANT COMPOSITION AND POST-LOGGING SUCCESSION AS COMPARED TO A NO-BURN SLASH TREATMENT? B. IF SO, WHAT ARE THE WILDLIFE HABITAT AND FORAGE PRODUCTION IMPLICATIONS ASSOCIATED WITH BURNING OR NO BURNING? C. IS THE TIME INTERVAL TO CANOPY CLOSURE, OR REFORESTATION PERIOD, AFFECTED BY FIRE? D. DOES MACHINE PILING (OR WINDROWING) AND BURNING PRODUCE COMPARABLE PATTERNS OF VEGETATION AND SUCCESSION FOUND UNDER SEPARATE TREATMENTS IN A. FUEL REDUCTION,SPECIES DIVERSITY,SUCCESSION,FUEL/BIOMASS ACCUMULATION,PRODUCTIVITY,ANIMALS,MANIPULATION COMPARISON

405. 05 168 A. IS IT PRACTICAL TO SUPPRESS MOUNTAIN MEADOW, OR SUBALPINE MEADOW, TREE INVASION BY LATE SEASON BURNING? B. IF SO, WHAT IS THE SUSCEPTIBILITY FOR THE DIFFERENT SPECIES AND AT WHAT AGE, OR HEIGHT CLASSES, CAN CONTROL BEST BE ACHIEVED? SUCCESSION,MORTALITY,VEGETATION,AGE,SIZE CLASS

406. 05 168 WHAT IS THE EFFECT OF INCREASED HEATING ON THE VIABILITY OF ROOT SYSTEMS OF BIG GAME SHRUBS? HEAT EFFECTS,ROOTS,SHRUBLAND

407. 05 168 WHAT SOCIOLOGICAL AND/OR PSYCHOLOGICAL IMPLICATIONS MUST BE EXAMINED IN ORDER TO EDUCATE THE PUBLIC FOR THE ACCEPTANCE OF FIRE AS A MANAGEMENT TOOL? EXPERIMENT ORIENTED QUESTION,PUBLIC REACTION,SOCIAL EFFECTS

408. 05 169 WHAT EFFECT DOES FIRE HAVE ON FUNGAL AND MICROBIAL SUCCESSION AND PROCESSES? E.G., IN THE AFTERMATH OF VARIOUS FIRE INTENSITIES, IN WHAT WAYS DO SPECIES, POPULATIONS, AND ACTIVITIES CHANGE IN COMPARISON WITH UNBURNED HABITATS: A. NITROGEN FIXATION B.

DECOMPOSITION-DECOMPOSER SPECIES SUCCESSION AND ACTIVITY. C. MYCORRHIZA FORMATION AND SUCCESSION OF MYCORRHIZA FUNGI D. SULPHUR FIXATION. E. ROOT PATHOGENS? FUNGUS,MICROORGANISM,SUCCESSION,DECOMPOSITION,FIRE INTENSITY,HEAT EFFECTS

409. 05 240 FIRE RESULTS IN RAPID RELEASE OF VARIOUS PLANT GROWTH ELEMENTS THAT ARE NORMALLY RELEASED IN SLOW DECAY. IS RAPID RELEASE LIKELY TO BENEFIT CERTAIN PLANTS AND IF SO, WHICH KIND? THIS COULD HELP TO DETERMINE PLANT SUCCESSION IN A FIRE SWEPT AREA. NUTRIENTS,VEGETATION,SUCCESSION

410. 05 240 INTENSE HEAT OXIDIZES MANY ELEMENTS AND CAUSES THEM TO DISPERSE AS GASES. DOES A SLOW BURNING FIRE CONSERVE MORE FOOD ELEMENTS FOR PLANTS, THUS STIMULATING RAPID PLANT GROWTH, THAN A FIERCELY HOT FIRE? NUTRIENTS,FIRE INTENSITY

411. 05 241 WHAT EFFECT DOES FIRE, IN CONIFEROUS FOREST HABITAT, HAVE ON BIRD, MAMMAL, INSECT, AND PLANT POPULATIONS AND ON THE SPECIES COMPOSITION: (1) UNDER DIFFERENT FIRE INTENSITIES? (2) IN "OLD GROWTH", AS OPPOSED TO THE VARIOUS STAGES OF FOREST REGENERATION AND GROUND SURFACE CONDITIONS? (3) IN VARIOUS CONIFEROUS FOREST TYPES? (4) UNDER DIFFERENT EXPOSURES AND ELEVATIONS? (5) AT VARIOUS TIMES OF YEAR OR SEASONS? WHY DO THESE CHANGES TAKE PLACE? HOW LONG DOES IT TAKE AN AREA TO RETURN TO ITS PRE-FIRE ANIMAL AND PLANT STATUS? POPULATION,BIRD,INSECT,SMALL MAMMAL,GAME ANIMAL,SUCCESSION

412. 05 247 WHEN CONTROLLED BURNING IS USED TO REHABILITATE 25 YEAR+ BRUSH SPECIES MANAGED FOR BIG GAME BROWSE, WHAT ARE THE MEASURED CHANGES IN NUTRIENT AND SEDIMENT LOADS OF DOWNSLOPE STREAMS? NUTRIENTS,STREAM,TOPOGRAPHY,SHRUBLAND,MOSAIC,ZONATION

413. 05 453 DOES SLASH DISPOSAL IMPROVE THE VISUAL EFFECT OF LOGGING? WHAT IS THE LONG RANGE VISUAL EFFECT? AESTHETICS,FUEL REDUCTION,PUBLIC REACTION,HUMAN DISTURBANCE

414. 05 453 HOW CAN WE PREDICT THE VOLUME OF SMOKE THAT WILL BE PRODUCED FROM AN ACREAGE? HOW WILL IT AFFECT AIR QUALITY UNDER GIVEN CONDITIONS? WHAT AFFECT DOES SPECIES, VOLUME OF SLASH, MOISTURE CONTENT, ATMOSPHERIC CONDITIONS HAVE ON SMOKE PRODUCTION FROM SLASH? AIR POLLUTION,AREA SIZE,AESTHETICS,FUEL REDUCTION,PUBLIC REACTION,MODEL,CLIMATE

415. 05 453 VERY LITTLE HAS BEEN DONE ON THE ECONOMICS OF SLASH DISPOSAL. I WOULD LIKE TO SEE SOME STUDIES ON THE ECONOMICS OF VARIOUS DISPOSAL METHODS AS RELATES TO THE AMOUNT OF SLASH REMAINING AND THE RESULTANT RISK, INCLUDING NO TREATMENT. ECONOMIC EFFECTS,PRESCRIBED FIRE,FUEL REDUCTION

416. 05 453 WHAT ARE THE EFFECTS OF SURFACE FIRE ON VARIOUS SPECIES IN RELATIONSHIP TO THEIR AGE AND BARK THICKNESS OR NATURAL FIRE RESISTANCE? FIRE INTENSITY,STEM,MORTALITY,GROUND FIRE

417. 05 453 WHAT IS THE EFFECT ON REFORESTATION OF REMOVING ALL LARGE CULL LOGS BUT LEAVING THE FIRE SLASH (6" DIAMETER AND SMALLER MATERIAL)? WHAT ARE THE OPTIMUM AMOUNTS (ANNUAL ACREAGES) OF SLASH THAT CAN BE LEFT UNTREATED AND STILL HAVE AN ACCEPTABLE RISK? REPRODUCTION,DECOMPOSITION,HUMAN DISTURBANCE,FUEL REDUCTION,AREA SIZE

418. 05 453 WHAT IS THE NET EFFECT OF DIFFERENT INTENSITIES OF FIRE ON REFORESTATION? REMOVAL OF CERTAIN AMOUNTS OF FUEL MAY BE CONSIDERED BENEFICIAL; BEYOND WHAT POINT MAY THAT BE CONSIDERED A DETRIMENT? FIRE INTENSITY,FIRE EFFECTS,FUEL REDUCTION,REPRODUCTION

419. 05 453 WHAT IS THE RELATIVE EFFECTIVENESS OF VARIOUS DISPOSAL METHODS AS OBSERVED IN FUEL VOLUMES IN UNHARVESTED AREAS AND RESIDUE AFTER VARIOUS TREATMENT? FUEL REDUCTION,ECONOMIC EFFECTS,MANIPULATION COMPARISON

420. 05 455 IN MANAGEMENT OF DOUGLAS-FIR WE ARE SUBSTITUTING REMOVAL OF TIMBER FOR FIRE, BLOWDOWN, ETC., THAT PROVIDED OPENINGS LEADING TO ESTABLISHMENT OF THE DOUGLAS-FIR STANDS WE NOW HAVE. WE THEN REGENERATE TO DOUGLAS FIR. THERE HAS BEEN SOME SUGGESTION THAT THIS PRACTICE OF MONOCULTURE IS BAD AND THAT CONTINUED SUCCESSIONS OF DOUGLAS-FIR WILL LEAD TO DEGENERATION OF SITES. DOES STUDY ALONG THESE LINES BEAR THIS OUT? IF SO, SHOULD WE ESTABLISH ARTIFICIALLY INDUCED CLIMAX STANDS TO BREAK THIS PATTERN? CAN PROVISION OF MINIMUM PROPORTIONS OF OTHER SPECIES IN THE DOUGLAS-FIR STANDS OVERCOME THE UNDESIRABLE EFFECTS OF PURE STANDS? SUCCESSION,FIRE EFFECTS,MOSAIC,CONIFEROUS FOREST,SPECIES DIVERSITY,PRODUCTIVITY

421. 05 455 SOME OPINION IS NOW BEING EXPRESSED THAT WE SHOULD USE PRESCRIBED FIRE TO REDUCE FUEL ACCUMULATION AND/OR MANIPULATE STOCKING LEVELS, UNDERSTORY PLANT COMMUNITIES, ETC., AND REDUCE WILD FIRE INTENSITIES. WHAT IS KNOWN OF FUEL QUANTITY-FIRE INTENSITY RELATIONSHIPS? ARE THERE ANY CONJECTURES ON PROJECTING THE OPTIMUM PERIODIC SCHEDULING OF PRESCRIBED BURNS? E.G. AT 10 YEARS AFTER INITIAL ESTABLISHMENT, 10 YEARS AFTER THAT, THEN HANDLE THE INCREASES IN FUELS BEYOND THAT POINT THROUGH COMMERCIAL THINNING, ETC? FUEL/BIOMASS ACCUMULATION,FUEL REDUCTION,FIRE INTENSITY,TIMING,FIRE FREQUENCY,PRESCRIBED FIRE,HUMAN DISTURBANCE,ECOSYSTEM,GROUND FIRE

422. 05 455 WHAT IS KNOWN OF THE ABILITY OF IMMATURE STANDS TO SURVIVE GROUND FIRES? IS THERE A MEANS OF PREDICTING TREE SURVIVAL IF PRESCRIBED FIRE IS USED AS A FUEL REDUCTION TOOL? GROUND FIRE,MORTALITY,MODEL,PRESCRIBED FIRE,FUEL REDUCTION

423. 05 457 IF FIRE PROTECTION ACTIVITIES HAVE BEEN A FACTOR IN CONVERSION OF PONDEROSA PINE STANDS TO ASSOCIATED SPECIES, HOW IMPORTANT IS IT? DOES IT REALLY MAKE A DIFFERENCE WHAT SPECIES IS THERE? SUCCESSION,FIRE EXCLUSION,SPECIES DIVERSITY,HUMAN ECOLOGY

424. 05 457 IS THE EFFECT OF WIDESPREAD IRRIGATION AN IMPORTANT FACTOR IN THUNDERSTORM FORMATION? LIGHTNING-CAUSED FIRE

425. 05 457 IS THERE A RELATIONSHIP BETWEEN THUNDERSTORM MOVEMENT AND MAGNETIC FIELDS IN THE EARTH? LIGHTNING-CAUSED FIRE

426. 05 457 THE NEWER SUSPENDED LOGGING SYSTEMS (HELICOPTER,ETC.) IN MANY CASES PRECLUDE ANY FORM OF SLASH DISPOSAL. ARE THE INCREASED FIRE RISKS BY NOT DOING SLASH DISPOSAL OFFSET BY THE GAINS IN RESOURCE PROTECTION FROM HUMAN DISTURBANCE? FUEL REDUCTION,HUMAN DISTURBANCE,FLAMMABILITY,MANIPULATION COMPARISON

427. 05 457 WHAT EFFECT DOES ACCESS REALLY HAVE ON ACRES BURNED? DOES GOOD ACCESS RESULT IN MAN-CAUSED FIRES AND MORE ACRES BURNED OR DOES IT REDUCE ACRES BURNED BY PROVIDING BETTER SURVEILLANCE AND QUICKER SUPPRESSION ACTION? HUMAN DISTURBANCE,GENERAL FIRE MANAGEMENT,MAN-CAUSED FIRE,AREA SIZE

428. 05 457 WHAT EFFECT WILL INTENSIVE SLASH DISPOSAL (NEARLY COMPLETE PILING AND BURNING) HAVE ON SOIL NUTRIENTS OVER AN EXTENDED PERIOD OF TIME? PRESCRIBED FIRE,FUEL REDUCTION,NUTRIENTS,TIMING

429. 05 458 BY PRESCRIBED BURNING PORTIONS OF SOUTHERN CALIFORNIA CHAPARRAL DRAINAGES, CAN THE 100,000 ACRE FIRES THAT WE NOW FREQUENTLY EXPERIENCE BE REDUCED? WHAT ARE THE ECOLOGICAL DIFFERENCES BETWEEN BURNING REGULARLY BY PRESCRIPTION AND INCURRING PERIODIC DISASTROUS FIRES? FIRE FREQUENCY,FIRE INTENSITY,AREA SIZE,SHRUBLAND,PRESCRIBED FIRE,COMMUNITY,GENERAL FIRE MANAGEMENT,FUEL REDUCTION

430. 05 458 IN THE DOUGLAS-FIR REGION (WESTSIDE CASCADES) WE NEED TO KNOW- WHICH IS BETTER FOR REGENERATION OF DOUGLAS-FIR SEEDLINGS: A) BURNING TO OBTAIN PLANTING SPOTS OR B) NOT BURNING AND SCALPING AFTER MOST SLASH HAS BEEN REMOVED MECHANICALLY? CONIFEROUS FOREST,REPRODUCTION,MANIPULATION COMPARISON,HUMAN DISTURBANCE,PRESCRIBED FIRE,FUEL REDUCTION,PLANTING,POPULATION

431. 05 460 HOW CAN FIRE EFFECTS ON SOIL, AS IT AFFECTS PRODUCTIVITY, BE MEASURED AND BE PREDICTED IN ADVANCE OF FIRE USE? MODEL,FIRE EFFECTS,SOIL,PRODUCTIVITY

432. 05 460 HOW CAN THE ECOLOGICAL EFFECTS OF LOGGING SLASH DISPOSAL BE MEASURED OR ESTIMATED? FUEL REDUCTION,HUMAN DISTURBANCE,MODEL

433. 05 460 WHAT IS THE RATE OF INCREASE IN AVAILABLE FUEL IN A CONIFEROUS FOREST WHERE FIRE IS EXCLUDED? FUEL/BIOMASS ACCUMULATION,CONIFEROUS FOREST

434. 05 462 ARE STANDS OF MIXED PONDEROSA PINE-WHITE FIR DESTINED TO BECOME WHITE FIR CLIMAX? WHAT PART CAN FIRE PLAY? SUCCESSION,FIRE EXCLUSION,FIRE EFFECTS,CONIFEROUS FOREST

435. 05 462 CAN IDAHO FESCUE BE MAINTAINED AS AN UNDERSTORY COMPONENT IN A PONDEROSA PINE STAND WHEN FIRE IS EXCLUDED? FIRE EXCLUSION,HERBAGE UNDERSTORY,CONIFEROUS FOREST

436. 05 463 FIRE PLAYS A VERY IMPORTANT ROLE IN PERPETUATING THE CONIFEROUS FORESTS OF THE COAST RANGE IN OREGON AND WASHINGTON. CLEARCUTTING WITHOUT BURNING FREQUENTLY LEADS TO CONVERSION TO RED ALDER OR OTHER BROAD LEAF SPECIES. CLEARCUTTING FOLLOWED BY BROADCAST BURNING AND PLANTING IS THE STANDARD PRACTICE FOR PERPETUATING CONIFERS. ONE OF THE PROBLEMS IN THIS PROCESS IS THAT DEER AND ELK FREQUENTLY BROWSE THE PLANTED STOCK. IN SOME CASES OUR PLANTATIONS ARE COMPLETELY WIPED OUT, IN OTHERS THE NEW GROWTH IS EATEN ANNUALLY CREATING SHRUBS. THIS SITUATION LASTS FROM 5 TO 7 YEARS FROM MY OBSERVATIONS: THEN THE ANIMALS SEEM TO LEAVE THE PLANTED TREES ALONE AND BROWSE ON OTHER VEGETATION. THIS PROCESS HAS TWO ADVERSE EFFECTS: (1) WE LOSE 5 TO 7 YEARS OF GROWTH DURING A ROTATION AND (2) WE HAVE TO USE ONE OR TWO APPLICATIONS OF HERBICIDES TO CONTROL THE COMPETING BRUSH SPECIES. MY SPECIFIC QUESTION IS: DOES BURNING CHANGE THE NUTRIENT BALANCE THEREBY MAKING CONIFER SPECIES MORE NUTRITIOUS OR MORE PALATABLE DURING CERTAIN SEASONS THAN THE NATIVE BROWSE SPECIES? THIS MAY BE MORE SIMPLY STATED: DOES A RELATIONSHIP EXIST BETWEEN BURNING AND ANIMAL DAMAGE TO CONIFEROUS TREES FOR THE PERIOD FOLLOWING BURNING? NUTRIENTS,HERBIVORY,GAME ANIMAL,PRODUCTIVITY,CONIFEROUS FOREST,SHRUBLAND,PLANTING,FUEL REDUCTION

437. 05 466 WHAT IS THE EFFECT OF VARIOUS FIRE INTENSITIES ON SOIL PRODUCTIVITY AS OBSERVED IN THE PREPARATION OF ORGANIC MATERIAL CONSUMED BY FIRE? CAN REMOVAL OF ALL ORGANIC MATTER PRECLUDE REGENERATION OF VEGETATION? SOIL,VEGETATION,FIRE INTENSITY,DUFF,REPRODUCTION

438. 05 468 IN A THINNING STAND WHERE THE CANOPY IS CLOSED, AT WHAT HEAT INTENSITIES CAN WE EXPECT NEEDLE DAMAGE TO THE TREES? CAN THIS AGAIN BE CORRELATED TO TONS OF SLASH PER ACRE? HOW CAN RATE OF SPREAD BE UTILIZED TO OUR ADVANTAGE? SHOULD IT BE SLOWER OR FASTER? FIRE INTENSITY,CROWN,CROWN BURN,FUEL/BIOMASS ACCUMULATION,HUMAN DISTURBANCE,CONIFEROUS FOREST

439. 05 468 IN THINNING STANDS, WHERE WE ARE REMOVING ABOUT 50% OF THE STEMS (LEAVING 50 TREES PER ACRE) AND THE RESIDUAL STAND AVERAGES 10 TO 16 INCHES DBH, WHAT HEAT INTENSITIES CAN BE STOOD? CAN THIS BE CORRELATED TO "TONS OF SLASH PER ACRE"? WHAT HAPPENS IF THE RESIDUAL

STAND IS 4 TO 6 INCHES DBH?   HUMAN DISTURBANCE,PRESCRIBED FIRE,FIRE INTENSITY,HEAT EFFECTS,FIRE EFFECTS,FUEL REDUCTION,STEM,MORTALITY

440. 05 468 IS THERE A SYSTEMATIC METHOD FOR THE FIELD MAN TO RAPIDLY DETERMINE THE SLASH TONNAGE PER ACRE BASED ON THE SPECIES, TYPE OF STAND, NUMBER OF TREES REMOVED AND PERCENT OF TREES UTILIZED? CAN THIS BE EQUATED TO HEAT INTENSITY UNDER A CONTROLLED BURN SITUATION IF SOIL AND FUEL MOISTURE IS KNOWN?   FUEL/BIOMASS ACCUMULATION,AREA SIZE,FIRE INTENSITY,SOIL-WATER RELATIONS,PRESCRIBED FIRE

441. 05 468 WHAT HEAT INTENSITIES CAN BE GENERATED BY GROUND FIRE IN A CONTROLLED SITUATION BEFORE WE SUSTAIN BARK DAMAGE AND THE KILLING OF THE TREES? DO WE HAVE TO PULL ALL SLASH AWAY FROM RESIDUAL TREES?   FIRE INTENSITY,HEAT EFFECTS,GROUND FIRE,MORTALITY,STEM,FIRE EFFECTS,ORGAN

442. 05 468 WHAT HEAT INTENSITIES CAN BE TOLERATED BY DOUGLAS-FIR BEFORE ROOT DAMAGE IS SUSTAINED? WHAT DEPTH OF SLASH AT WHAT MOISTURE CONTENT WILL CREATE WHAT INTENSITY OF HEAT? WHAT CORRELATION IS THERE TO SOIL TYPE AND SOIL DEPTH AND HEAT DAMAGE TO THE ROOT SYSTEM OF DOUGLAS-FIR? SUGAR PINE?   HEAT EFFECTS,FIRE INTENSITY,CONIFEROUS FOREST,ROOTS,ORGAN,FUEL REDUCTION,SOIL,COMMUNITY

443. 05 628 COULD FIRE BE USED ON A MIXED DECIDUOUS - CONIFEROUS WOODLAND IN SUCH A WAY AS TO ENCOURAGE THE DECIDUOUS TREES (E.G. OAK, MAPLE) WHILE SETTING BACK CONIFEROUS INVASION (E.G. DOUGLAS FIR, GRAND FIR)? IF SO, HOW AND WHEN IN THE ANNUAL CYCLE?   DECIDUOUS FOREST,CONIFEROUS FOREST,SAVANNA-WOODLAND,COMPETITION,TIMING,PRESCRIBED FIRE,SUCCESSION

444. 05 628 HOW OFTEN WOULD A MANAGED FIRE BE REQUIRED IN A WESTERN OREGON SECOND GROWTH MIXED FOREST TO PROMOTE CONTINUED HIGH WILDLIFE USE?   TIMING,FIRE FREQUENCY,WILDLIFE,PRESCRIBED FIRE

445. 05 628 WHAT TYPE OF FIRE BARRIERS CAN BE UTILIZED ON SMALL AREAS TO EFFECTIVELY CONTROL FIRE SPREAD BUT STILL NOT CAUSE EXTENSIVE MECHANICAL DAMAGE TO FRAGILE ECOSYSTEMS?   HUMAN DISTURBANCE,GENERAL FIRE MANAGEMENT,AREA SIZE

446. 05 746 AFTER A SEVERE CROWN FIRE WHAT IS THE BEST METHOD TO RE-ESTABLISH A TIMBER STAND FOR CERTAIN SOIL TYPES AND MOISTURE CONDITIONS? PLANT OR SEED? SIZE OF STOCK? METHOD OF PLANTING? USE OF CONTAINERIZED STOCK? PLANT AS SOON AS POSSIBLE OR WAIT A NUMBER OF YEARS BEFORE PLANTING?   CROWN BURN,REPRODUCTION,PLANTING,SEED,TIMING,SOIL

447. 05 746 ARE BARK BEETLES ATTRACTED TO FIRE EVEN AFTER A LIGHT PRESCRIBED BURN?   FIRE EFFECTS,INSECT,PRESCRIBED FIRE

448. 05 746 WHAT EFFECT DOES THE BURNING OF LOGGING SLASH ON CLEAR CUT AREAS HAVE ON THE SOIL AND STAND RE-ESTABLISHMENT IF THE SLASH IS PILED ALONG WITH HEAVY MATERIAL SUCH AS CULL LOGS? IF THE EFFECTS ARE GREAT, HOW LONG BEFORE THE SOIL RECOVERS? FIRE INTENSITY,FUEL REDUCTION,HUMAN DISTURBANCE,SOIL,REPRODUCTION

449. 05 746 WHAT EFFECT DOES THE SEEDING OF GRASSES ON A FIRE AREA HAVE ON PLANTED TREES? DOES IT INCREASE OR DECREASE THE CHANCE OF SURVIVAL OF THE PLANTED TREES? IF GRASS IS SEEDED, SHOULD THIS BE DONE JUST PRIOR TO PLANTING TREES, OR ONE OR TWO YEARS EARLIER? TIMING,HERBAGE UNDERSTORY,PLANTING,FIRE EFFECTS,REPRODUCTION,COMPETITION

450. 05 746 WHAT IS THE INCIDENCE OF SEEDLINGS WHERE SLASH PILES HAVE BEEN BURNED IN PARTIAL CUT AREAS? REPRODUCTION,ASH,CHARCOAL,NUTRIENTS,FUEL REDUCTION,HUMAN DISTURBANCE

451. 05 831 THERE IS A NEED FOR DEVELOPING MODELS TO SHOW ACRES SAVED FROM BURNING AND ASSOCIATED BRUSH CONTROL WITH VARIOUS LEVELS OF PROTECTION. THE COST PLUS LOSS APPROACH DOESN'T GIVE INSIGHT TO WHAT IS AN ADEQUATE LEVEL OF PROTECTION UNDER A GIVEN SET OF CIRCUMSTANCES. GENERAL FIRE MANAGEMENT

452. 05 831 THERE IS A NEED FOR MORE EMPHASIS ON FUELS MANAGEMENT: PARTICULARLY IN REGARDS TO DETERMINING NEEDS AND METHODS FOR FUEL REDUCTION, THE ASSOCIATED BENEFIT/COST AND FISCAL RESPONSIBILITIES (PUBLIC OR LANDOWNER). GENERAL FIRE MANAGEMENT

453. 06 171 IN THE BLACK HILLS, SOUTH DAKOTA, PONDEROSA PINE OFTEN GROWS IN VERY DENSE "DOG HAIR" STANDS. THESE STANDS APPEAR TO BE MOST COMMON ON SOILS DERIVED FROM METAMORPHOSED PRECAMBRIAN QUARTZ-MICA SCHISTS. THERE IS GOOD EVIDENCE THAT THE PONDEROSA PINE FORESTS OF THE BLACK HILLS HAVE A LONG HISTORY OF FIRES. MY QUESTION IS TWO-PARTED: ARE THE DENSE "DOG HAIR" PONDEROSA PINE STANDS DIRECTLY RELATED TO THE FIRE HISTORY OF THE SITE? IF SO, WHAT IS THE INTERACTION OF THE GEOLOGY-SOIL FACTOR AND FIRE WHICH TENDS TO PRODUCE "DOG HAIR" STANDS ON SOME SITES AND NOT ON OTHERS? FUEL/BIOMASS ACCUMULATION,DENSITY,FIRE FREQUENCY,SOIL

454. 06 250 WHAT IS THE EFFECT OF DIFFERENT DENSITIES OF ELK POPULATIONS ON REPRODUCTION OF ASPEN (1) WITH FIRE EXCLUSION, AND (2) WITH FIRES OF VARIOUS FREQUENCIES AND INTENSITIES? FIRE EXCLUSION,FIRE FREQUENCY,FIRE INTENSITY,REPRODUCTION,DECIDUOUS FOREST,GAME ANIMAL,POPULATION,DENSITY,REPRODUCTION,HERBIVORY

455. 06 297 HOW MANY OF THE UNDERSTORY SPECIES ARE ACTUALLY KILLED BY THE FIRE, OR WHAT ROLE DOES ROOT SPROUTING PLAY IN REVEGETATION OF BURNED AREAS? HERBAGE UNDERSTORY,SHRUB UNDERSTORY,MORTALITY,ROOTS,REPRODUCTION

456. 06 297 WHAT CHANGES IN AVAILABLE FORAGE OCCUR IN A BURN, AND WHAT FACTORS INFLUENCE THE UTILIZATION OF THESE FOOD SOURCES? HERBIVORY

457. 06 297 WHAT FACTORS ARE IMPORTANT TO LODGEPOLE PINE REGENERATION, AND WHAT, BESIDES FIRE INTENSITY, AFFECTS REPRODUCTION DENSITY FOLLOWING FIRE? REPRODUCTION,FIRE INTENSITY,VEGETATION

458. 06 297 WHAT IS THE FATE OF MINERALS RELEASED BY THE FIRE? NUTRIENTS

459. 06 297 WHAT PARAMETERS AFFECT NATURAL FUEL ACCUMULATION AND DEGRADATION, AND HOW DO THESE PARAMETERS VARY IN THE DIFFERENT COMMUNITY TYPES OR HABITAT TYPES? FUEL/BIOMASS ACCUMULATION,MORTALITY,DECOMPOSITION

460. 06 298 CAN WE EXPECT SUCCESSFUL REGENERATION OF ASPEN AND OTHER SHRUB SPECIES FOLLOWING FIRE ON A RANGE THAT RECIEVES A HEAVY LEVEL OF UNGULATE BROWSING? HOW MANY ACRES NEED BE BURNED, AND UNDER WHAT CONDITIONS, IF ONE IS TO EXPECT SUCCESSFUL REGENERATION? IT SEEMS TIMELY TO INVESTIGATE THIS RELATIONSHIP IN OTHER REGIONS OF THE WEST WHERE UNGULATE BROWSING HAS BEEN ATTRIBUTED TO THE DEMISE OF ASPEN. GAME ANIMAL,DECIDUOUS FOREST,HERBIVORY,AREA SIZE,REPRODUCTION,SUCCESSION,SHRUBLAND

461. 06 298 IT IS EVIDENT THAT SUBALPINE FIR HAS BEEN HIGHLY IMPORTANT IN THE DIET OF WINTERING MOOSE OVER THE PAST SEVERAL DECADES. EXTENDED OBSERVATION OVER SEVERAL YEARS INDICATES THAT THE AVAILABILITY OF SUBALPINE FIR IS ON THE DECLINE OWING TO ACCUMULATIVE HEAVY UTILIZATION AND UNAVAILABILITY OWING TO GROWTH. WE NEED RESEARCH DATA ON WHAT VEGETATIVE TYPES, UNDER WHAT CONDITIONS, AND IN WHAT TIME PERIOD WE MIGHT EXPECT TO GET SUBALPINE FIR FOLLOWING BURNING. WHAT IS THE TIME LAG OF SUBALPINE FIR REGENERATION IN A LODGEPOLE PINE STAND FOLLOWING BURNING COMPARED WITH FOLLOWING CLEARCUTTING? SUCCESSION,GAME ANIMAL,HERBIVORY

462. 06 298 WHAT IS THE MONETARY LOSS DUE TO WILDFIRE IN A SAGEBRUSH-ASPEN OR ASPEN-CONIFER ASSOCIATION? (WE HEAR SOME WILD FIGURES THROWN AROUND. IT APPEARS TIMELY THAT A COMPARISON OF SUPPRESSION COSTS BE MADE WITH ACTUAL DAMAGE. A CALCULATION OF WILDLIFE BENEFITS, IN DOLLARS, IN THESE TYPES MIGHT SERVE TO PUT US ON A COURSE OF FIRE MANAGEMENT INSTEAD OF THE PRESENT HEAD-IN-THE-SAND APPROACH OF TOTAL SUPPRESSION.) FIRE EXCLUSION,ECONOMIC EFFECTS,GENERAL FIRE MANAGEMENT

463. 06 298 WHAT IS THE SUCCESSIONAL SEQUENCE OF DECIDUOUS SPECIES SUCH AS MOUNTAIN ASH, SCOULER WILLOW, BOG BIRCH, RUSSET BUFFALO BERRY, BEARBERRY HONEY SUCKLE, AND OTHER SHRUBS WHICH ARE UTILIZED WHEN AVAILABLE BY WINTERING MOOSE? WHAT TAKES PLACE WHEN AN AREA CONTAINING ONLY REMNANTS OF THESE SPECIES BURNS OVER? DOES IT TAKE SEVERAL YEARS OR SEVERAL DECADES FOR THESE SPECIES TO FILL IN AND BECOME REESTABLISHED? OR, ARE SOME PLANT

ASSOCIATIONS SO FAR GONE THAT THEY STAND NO CHANCE OF BEING REJUVINATED BY FIRE? - (IT APPEARS WE NEED SOME PRESCRIBED BURNS AND INTENSIVE SAMPLING TO DETERMINE THESE RELATIONSHIPS. IT IS EVIDENT WE NEED INFORMATION OF THIS NATURE IN ORDER TO DETERMINE WHETHER CERTAIN SUBALPINE FIR TYPES, NOW SUPPORTING WINTERING MOOSE, COULD LIKEWISE SUPPORT MOOSE IN EARLY STAGES OF SUCCESSION. IT IS RATHER CLEAR THAT MOST WILDLIFE SPECIES ARE BENEFITED BY FIRE AND DO WELL IN EARLY STAGES OF SUCCESSION; HOWEVER, IT IS NOT SO EVIDENT WITH RESPECT TO MOOSE.) SUCCESSION,GAME ANIMAL,SHRUBLAND,HERBIVORY,REPRODUCTION

464. 06 299 DETERMINE THE PREHISTORIC (I.E. PRE EURO AMERICAN MAN) FREQUENCY OF FIRE IN VARIOUS CONIFEROUS FOREST TYPES - I.E., FREQ.,SIZE, INTENSITY USING ANALYSIS OF FIRE SCARS -INFERENCES FROM EARLY PHOTOS, ETC. EXPERIMENT ORIENTED QUESTION

465. 06 300 HOW DO THE BIOLOGICAL AND CHEMICAL EFFECTS OF PRESENTLY USED LOGGING PRACTICES IN VARIOUS FOREST TYPES COMPARE TO THE BIOLOGICAL AND CHEMICAL EFFECTS OF PAST WILD FIRES IN THESE FOREST TYPES? CAN LOGGING TECHNIQUES BE MODIFIED SO THAT THESE EFFECTS ARE QUITE SIMILAR? MANIPULATION COMPARISON

466. 06 300 HOW DOES FIRE SUPPRESSION, WHICH RESULTS IN INCREASES IN SHRUB AND FOREST COVER, AFFECT THE HYDROLOGIC CYCLE IN SPECIFIC ECOSYSTEM TYPES? DOES DECREASED STREAM FLOW OR LOWERING OF THE WATER TABLE COMMONLY RESULT? FIRE EXCLUSION,HYDROLOGY

467. 06 300 THE PROCESSES OF DECOMPOSITION FOLLOWING FIRE, AND IN THE ABSENCE OF FIRE, NEED QUALITATIVE AND QUANTITATIVE STUDY. HOW DO ORGANISMS INVOLVED DIFFER? DECOMPOSITION,MICROORGANISM

468. 06 300 QUANTITATIVE DOCUMENTATION IS NEEDED FOR FUEL BUILDUP OR REDUCTION OVER TIME IN VARIOUS ECOSYSTEM TYPES. SOME RESOLUTION IS NEEDED BETWEEN THE CONCEPTS THAT "FIRE BREEDS MORE FIRE" AND THAT "AFTER LONG ENOUGH FIRE SUPPRESSION, FIRE BECOMES INEVITABLE." FUEL/BIOMASS ACCUMULATION,EXPERIMENT ORIENTED QUESTION

469. 06 471 CAN WE PREDICT ELAPSED TIME WHEN NATURAL REGENERATION WILL FOLLOW NATURAL OR MAN-CAUSED FIRES? ALSO, IF NATURAL REGENERATION DOES NOT FOLLOW FIRE, IS THIS DUE TO A NUTRIENT OR SOIL LIMITATION WHICH WOULD DISCOURAGE SEEDING OR PLANTING? IF SO, FOR HOW LONG A TIME IS THIS DEFICIENCY A SIGNIFICANT FACTOR? REPRODUCTION,FIRE EFFECTS,PLANTING,SOIL,NUTRIENTS

470. 06 471 WHAT EFFECT DOES SLASH LEFT ON THE GROUND (AS COMPARED TO DUE TO BURNING) HAVE ON MOISTURE RETENTION CAPABILITIES OF THE SOIL? ALSO,WHAT RELATION IS THERE TO THE EFFECTS OF SNOW ACCUMULATION AND/OR RETENTION AND POTENTIAL SOIL MOISTURE CONTENT? FUEL REDUCTION,HUMAN DISTURBANCE,MANIPULATION COMPARISON,SNOW,SOIL-WATER RELATIONS,FIRE EFFECTS

471. 06 474 WHAT EFFECTS DO ASHES HAVE ON STREAMS IN RELATION TO AQUATIC LIFE FROM LODGEPOLE SITES? SPRUCE-FIR SITES? WHAT CONCENTRATIONS OF ASH ARE HARMFUL? SHOULD CATCH BASINS BE USED TO KEEP ASH OUT OF STREAMS? ASH,STREAM,FIRE EFFECTS,CONIFEROUS FOREST

472. 06 478 IS ORGANIC FERTILIZATION PRACTICAL IN SITUATIONS WHERE HOT FIRES HAVE DESTROYED SOIL NUTRIENTS? SOIL,NUTRIENTS,HEAT EFFECTS,FIRE EFFECTS,HUMAN DISTURBANCE

473. 06 666 WHAT ARE THE EFFECTS (PHYSICAL) OF FIRE ON SMALL COLD WATER DRAINAGES WITH REFERENCE TO SILT, TEMPERATURE CHANGES IN STREAM PHYSIOGNOMY AND DURATION OF IMPACT? WHAT ARE THE EFFECTS (BIOLOGICAL) ON AQUATIC FAUNA, TROUT SPAWNING AREAS AND DURATION OF IMPACT? STREAM,FIRE EFFECTS,SOIL EROSION,TIMING,FISH,ANIMALS,ECOSYSTEM

474. 05 667 IS THE SAVANNA OF THE HUDSONIAN ZONE IN NORTHWEST WYOMING THE RESULT OF PERIODIC WILDFIRE? IF SO, WHAT WILL BE THE LONG-TERM EFFECT ON THIS REGION IF FIRES ARE CONTROLLED BY MAN? GRASSLAND,FIRE EFFECTS,FIRE HISTORY,FIRE EXCLUSION,ECOSYSTEM

475. 06 667 WOULD IT BE POSSIBLE TO COMPILE AND PUBLISH INTO ONE COMPREHENSIVE REPORT THE MANY ASPECTS OF FIRE AND ITS EFFECT ON BROWSE? INCLUDED SHOULD BE RECOMMENDATIONS FOR MANAGEMENT. FIRE EFFECTS,SHRUBLAND,WILDLIFE,GAME ANIMAL,GENERAL FIRE MANAGEMENT

476. 06 668 WHAT CHEMICAL CONSTITUENTS CAN BE EXPECTED IN RUNOFF FROM BURNED OVER FOREST LANDS? WHAT CHANGES IN SURFACE WATER QUANTITY AND QUALITY CAN BE EXPECTED FROM A BURNED OVER DRAINAGE AREA? STREAM,FIRE EFFECTS,SOIL-WATER RELATIONS

477. 05 668 WHAT EFFECTS DO FIRE ROAD AND FIRE LINE CONSTRUCTION HAVE ON SILT DEPOSITION IN STREAMS WITHIN AND BELOW THE FIRE AREA? HUMAN DISTURBANCE,STREAM,SOIL EROSION

478. 06 670 FROM A STANDPOINT OF STREAM MORPHOLOGY AND RESIDENT TROUT POPULATIONS, WHAT ARE THE ADVANTAGES (IF ANY) AND DISADVANTAGES OF FIRE? STREAM,FISH,FIRE EFFECTS

479. 06 671 DOES FIRE STERILIZE THE SOIL THUS REDUCING THE NUTRIENTS ENTERING A STREAM AND THUS REDUCING THE PRODUCTIVITY OF THE STREAM? HOW LONG A PERIOD IS REQUIRED FOR THE SOIL TO RETURN TO ITS ORIGINAL COMPOSITION? STREAM,NUTRIENTS,PRODUCTIVITY,SOIL,HEAT EFFECTS

480. 06 671 IN FIRE SUPRESSION ACTIVITIES, WHAT EFFECT DOES SLURRY HAVE UPON THE WATER CHEMISTRY OF THE STREAM AND THE ORGANISMS LIVING IN THE WATERS? CHEMICAL RETARDANT EFFECTS,STREAM

481. 06 723 DOES THE SUPPRESSION OF FIRE HISTORICALLY HAVE A VALUABLE COST BENEFIT RATIO IF TIMBER PRODUCTION AND COSTS OF SUPPRESSION ALONE ARE CONSIDERED? ECONOMIC EFFECTS,GENERAL FIRE MANAGEMENT

482. 06 723 IN THE ROCKY MOUNTAIN AREA, IN WHAT SEASON WOULD A FIRE HAVE MOST BENEFICIAL VALUE TO ELK AND MULE DEER HABITAT IN A) SPRUCE COMMUNITIES? B)PONDEROSA COMMUNITIES? C)SAGE BRUSH-JUNIPER COMMUNITIES? GAME ANIMAL,FIRE EFFECTS,TIMING,COMMUNITY

483. 06 723 IS THE CHAINING (UP-ROOTING AND KILLING) OF PINON-JUNIPER GROSSLY SIMILAR IN ITS EFFECTS ON MULE DEER AND OTHER WILDLIFE HABITAT TO FIRE-BURNED AREAS OF SIMILAR SIZE AND SHAPE? MANIPULATION COMPARISON,WILDLIFE,GAME ANIMAL,AREA SIZE

484. 06 724 DOES FIRE(NATURAL OR SLASH BURNING) HAVE ANY MEASURABLE EFFECT ON THE LEVELS OF HEART ROT AND/OR BUTT ROT FOUND IN SUCCESSOR STANDS? DISEASE,SUCCESSION,STEM,FIRE EFFECTS

485. 06 724 WHAT ARE THE EFFECTS OF EXCLUDING FIRE FROM LODGEPOLE-ASPEN ASSOCIATIONS WHEN MUCH OF THE LODGEPOLE HAS BEEN KILLED BY BEETLES, OR MUCH OF THE ASPEN HAS BEEN KILLED BY ELK? WHAT WOULD BE THE EFFECTS OF BURNING ON COMPOSITION AND TIME OF ESTABLISHMENT OF SUCCESSOR STANDS? SUCCESSION,DECIDUOUS FOREST,CONIFEROUS FOREST,INSECT,FUEL/BIOMASS ACCUMULATION,GAME ANIMAL,FIRE EXCLUSION

486. 06 724 WHAT ARE THE EFFECTS OF FIRE AND FIRE EXCLUSION IN ASSOCIATED ASPEN AND LODGEPOLE STANDS ON THE POPULATION GROWTH OF RUFFED GROUSE? BIRD,FIRE EXCLUSION,FIRE EFFECTS,DECIDUOUS FOREST,CONIFEROUS FOREST

487. 06 724 WHAT ARE THE SHORT AND LONG TERM EFFECTS OF FIRE ON WATER QUALITY IN SMALL STREAMS? SEDIMENT, CHEMICAL COMPONENTS, AND WATER TEMPERATURES ARE OF INTEREST PARTICULARLY AS THEY RELATE TO TROUT HABITAT AND SPAWNING AREAS. HOW LONG WOULD THE SEVERAL EFFECTS LAST? STREAM,FIRE EFFECTS,NUTRIENTS,FISH

488. 07 094 GIVEN COMPLETE AND CONTINUOUSLY SUCCESSFUL PROTECTION FROM FIRE IN SEQUOIA GROVES, WHAT EVENTUAL PLANT COMMUNITY COMPOSITION WOULD DERIVE? IN SUCH CIRCUMSTANCES, AND BARRING OTHER CATASTROPHIC EVENTS, WHAT LENGTH OF LIFE MIGHT ACCRUE TO THE GIANT SEQUOIA? FIRE EXCLUSION,VEGETATION,SPECIES DIVERSITY,SUCCESSION,COMPETITION,AGE

489. 07 094 IN A PROGRAM OF REGULAR PRESCRIPTION BURNING AIMED AT FIRE HAZARD REDUCTION, WILL THE BOUNDARIES OF INDIVIDUAL GROVES CHANGE AS A RESULT? IN OTHER WORDS, WHAT HAS BEEN THE ROLE OF FIRE (IF ANY) IN DELIMITING THE PRESENT RATHER ISOLATED SEQUOIA GROVES? PRESCRIBED FIRE,FUEL/BIOMASS ACCUMULATION,ECOTONE,AREA SIZE

490. 07 094 WHAT IS THE RELATIONSHIP OF SOIL TEMPERATURE DIFFERENCES RESULTING FROM WILD AND/OR PRESCRIPTION

FIRES AND THE SUCCESS OR LACK THEREOF OF SEQUOIA REGENERATION? HOW DO OTHER ASSOCIATE PLANTS RESPOND TO THIS HEAT DIFFERENTIAL? FIRE INTENSITY,MANIPULATION COMPARISON,MICROCLIMATE,REPRODUCTION,COMPETITION

491. 07 095 HOW DOES WATER-YIELD CHANGE FOLLOWING WILDFIRE (AND CONTROLLED BURNS, INCLUDING SLASH DISPOSAL)? (AMOUNT, TIMING, AND DURATION.) HYDROLOGY

492. 07 097 IF NATURAL FIRE FREQUENCIES COULD BE ALLOWED IN SOME AREAS OF SOUTHERN CALIFORNIA CHAPARRAL BORDERING ON PINE FOREST, WHAT WOULD BE THE RESPONSE OF THE ADJACENT PINE FOREST IN TERMS OF FIRE FREQUENCY AND FUEL COMSUMPTION? ZONATION,FIRE FREQUENCY,FIRE BEHAVIOR,FUEL/BIOMASS ACCUMULATION,FIRE EXCLUSION,FUEL REDUCTION

493. 07 174 WHAT EFFECT DO DIFFERENT FIRE SUPPRESSION ACTIVITIES HAVE ON FIRE INTENSITY? DOES THE LENGTH OF TIME BETWEEN FIRE LEAD TO MORE INTENSE FIRES? PERIPHERAL TO THIS ARE THE FOLLOWING QUESTIONS. WHAT IS THE RELATIONSHIP BETWEEN FIRE INTENSITY (HEAT FLUX) AND: (1) THE AMOUNT OF LITTER AND VEGETATION DESTROYED DURING FIRE: (2) THE AMOUNT OF NITRATE, AMMONIUM, AND TOTAL NITROGEN REMAINING AFTER A FIRE AND (3) THE PRODUCTION OF A WATER REPELLENT SOIL CONDITION? FIRE EXCLUSION,FUEL/BIOMASS ACCUMULATION,FIRE INTENSITY,FIRE BEHAVIOR,FUEL REDUCTION,NUTRIENTS,SOIL-WATER RELATIONS

494. 07 176 I BELIEVE THAT IT WOULD BE WORTH-WHILE TO INVESTIGATE THE IMPORTANCE OF DRY RAVEL MOVEMENT AFTER FIRE ON SLOPES WITH RESPECT TO THE LOSSES OF NUTRIENTS FROM BURNED SLOPES AND ITS EFFECT ON SEED GERMINATION. THE LATTER EFFECTS COULD INCLUDE CARRYING SEED FROM THE STEEP SITES, COVERING SEED AND PROTECTING IT FROM RODENTS, OR PERHAPS BURYING IT TOO DEEPLY FOR GERMINATION AND ESTABLISHMENT. SOIL EROSION,TOPOGRAPHY,NUTRIENTS,SEED,REPRODUCTION,HERBIVORY

495. 07 252 CAN THE ALTERATION OF THE VEGETATION, IN TERMS OF HORIZONTAL AND VERTICAL DIVERSITY, BE USED TO PREDICT REACTIONS BY ANIMAL POPULATIONS IN TERMS OF SPECIES OCCURRENCE, DISTRIBUTION, AND DENSITY? VEGETATION,ANIMALS,SPECIES DIVERSITY,POPULATION

496. 07 252 WHAT IS THE OPTIMUM (OR DESIRABLE) SIZE AND/OR SHAPE OF A BURN THAT WOULD RESULT IN A MORE DIVERSE ANIMAL COMPOSITION THAT INCLUDES THE CLIMAX COMMUNITY SPECIES? MOSAIC,AREA SIZE,SPECIES DIVERSITY,ANIMALS

497. 07 253 ARE MAN'S METHODS AND TIMBER HARVEST MORE HARMFUL IN WATERSHED ECOLOGY, STREAM BIOLOGY AND STREAM MECHANICS THAN WOULD BE THE EFFECTS OF NATURAL FIRES IN THE SAME WATERSHED? MANIPULATION COMPARISON,STREAM,WATERSHED

498. 07 257 HOW CAN PRESCRIBED BURNING BE USED TO MAXIMIZE BROWSE AND HERBACEOUS VEGETATION PRODUCTION IN THE UNDERSTORY? PRESCRIBED FIRE,SHRUB UNDERSTORY,PRODUCTIVITY

499. 07 257 HOW DOES FIRE AFFECT THE NUTRITIONAL VALUES OF SEEDS ON THE SURFACE OF THE SOIL? NUTRIENTS,SEED

500. 07 257 HOW DOES PRESCRIBED BURNING, FOR CONTROL OF LODGEPOLE PINE, AFFECT ADJACENT MEADOWS? MOSAIC

501. 07 257 HOW DOES THE BURNED ENVIRONMENT AFFECT THE BEHAVIOR OF RODENTS (FOOD HUNTING AND MOVEMENT PATTERNS, COMPETITION)? ARE RODENTS MORE SUSCEPTIBLE TO PREDATION AFTER A FIRE? HOW DO SMALL MAMMAL REPRODUCTIVE PATTERNS RESPOND TO HABITAT CHANGES RESULTING FROM FIRE? ANIMAL BEHAVIOR,SMALL MAMMAL,EXPERIMENT ORIENTED QUESTION,PREDATION,REPRODUCTION

502. 07 257 WHAT ARE THE UNDERSTORY SUCCESSIONAL PATTERNS, IN RELATION TO DEER HABITAT, AFTER BURNING IN TRUE FIR, PINE, AND LODGEPOLE TYPES? SHRUB UNDERSTORY,SUCCESSION,SPECIES DIVERSITY

503. 07 302 HOW DO FUEL LOADS CHANGE WITH TIME IN MAJOR FOREST TYPES? FUEL/BIOMASS ACCUMULATION

504. 07 302 WHAT IS THE FUEL SITUATION ON A SITE RECENTLY PRESCRIBED BURNED--INVOLVING HOW MUCH DEAD AND LIVING FUELS ARE LEFT ON THE GROUND, IN THE UNDERSTORY, AND IN THE CROWN? FUEL/BIOMASS ACCUMULATION

505. 07 483 WHAT IS THE EFFECT OF REPEATED PRESCRIBED GROUND FIRES (EVERY 5 TO 8 YEARS), ON SHADED FUEL BREAKS, AS SEEN IN CONCENTRATIONS OF AVAILABLE SOIL NUTRIENTS? CAN THE FREQUENCY AND TIMING OF SUCH BURNING BE DONE SO AS TO PERPETUATE AN ARRESTED GRASS ECOSYSTEM? IF GRADUAL DEPLETION OF NECESSARY SOIL NUTRIENTS OCCURS, CAN THIS BE OFFSET BY PURPOSELY FERTILIZING THE FUEL BREAKS? PRESCRIBED FIRE,GROUND FIRE,NUTRIENTS,FIRE FREQUENCY,TIMING,SUCCESSION

506. 07 491 A NEED FOR DATA WHICH MIGHT INDICATE APPROXIMATELY HOW OFTEN NATURAL FIRE OCCURRED IN VARIOUS VEGETATIVE TYPES PRIOR TO MAN'S INTERVENTION. FIRE FREQUENCY

507. 07 491 WHAT EFFECTS WILL HOT SLASH BURNING HAVE ON SOILS AND REGENERATION? REPEATED BURNINGS? FIRE INTENSITY,SOIL,REPRODUCTION

508. 07 495 IS THERE REALLY A FUEL BUILD-UP DUE TO EFFECTIVE SUPPRESSION THAT EXCEEDS THAT WHICH OCCURRED NATURALLY? THERE MAY BE AN INCREASE IN TOTAL BIOMASS, BUT DOES THE ACCUMULATION CONSIST OF FINE FUELS THAT CONTRIBUTE TO FIRE INTENSITY, OR DOES THE ACCUMULATION CONSIST OF TREE BOLES AND DOWN LOGS, WHICH ACTUALLY CONTRIBUTE VERY LITTLE TO THE MOVING FLAME FRONT? FUEL/BIOMASS ACCUMULATION,FIRE EXCLUSION,FIRE BEHAVIOR

509. 07 495 WHAT ARE THE SUCCESSIONAL TRENDS IN THE AREA AND HOW ARE THEY INTERRUPTED BY FIRE AT VARIOUS STAGES? SUCCESSION

510. 07 495 WHAT EFFECTS CAN BE EXPECTED FROM EXCEEDING THE NATURAL PERIODICITY, SUCH AS WE ARE PROBABLY DOING IN AREAS OF HIGH MAN-CAUSED FIRES? WHAT REBURN FREQUENCY IS NECESSARY TO CAUSE A CONIFER STAND TO REVERT TO BRUSH FIELDS IN THIS AREA? FIRE FREQUENCY,SUCCESSION,SHRUBLAND

511. 07 495 WHAT WAS THE AVERAGE FIRE PERIODICITY PRIOR TO SUPPRESSION? WHAT WAS THE NATURE OF FIRE PRIOR TO SUPPRESSION, E.G. WERE THEY LOW INTENSITY SURFACE FIRES OR HIGH INTENSITY CROWN FIRES? ASSUMING FIRES OF BOTH TYPES OCCURRED, WHICH TYPE FIRE PLAYED THE DOMINANT ROLE IN SHAPING THE FOREST BIOME? FIRE FREQUENCY

512. 07 502 WHAT EFFECTS DOES FIRE HAVE ON ARCHEOLOGICAL ARTIFACTS LYING ON THE GROUND SURFACE OR IMMEDIATELY BELOW IT IN REGARDS TO THEIR FUTURE CARBON 14 DATING? HUMAN ECOLOGY

513. 07 504 HOW CAN FUELS BE ACCURATELY DESCRIBED IN ORDER TO RELATE THEM TO HAZARD RATINGS, SO THAT THEY CAN READILY BE RECOGNIZED BY PEOPLE WITH LIMITED EXPERIENCE? FUEL/BIOMASS ACCUMULATION,EXPERIMENT ORIENTED QUESTION

514. 07 507 HOW CAN WE ESTIMATE FIRE BEHAVIOR FOR VARIOUS FUEL TYPES, AND THE CHANGES CAUSED BY ADDING LOGGING SLASH AND THINNING SLASH? FIRE BEHAVIOR,FUEL/BIOMASS ACCUMULATION

515. 07 507 HOW MUCH ASH CAN WE HAVE AND STILL GROW TREES? CAN WE PLANT IN SLASH PILES? ASH,PRODUCTIVITY

516. 07 507 WHAT ARE THE REASONS UNBURNED ISLANDS ARE LEFT WHEN SLOPE, WINDS, FUELS, ETC. ALL INDICATE THE WHOLE SLOPE SHOULD BURN CLEANLY? FIRE BEHAVIOR,FUEL REDUCTION

517. 07 634 WILL THE CARBON CREATED BY BURNING TIE UP CERTAIN HERBICIDES THAT MIGHT BE USED TO CONTROL THE EMERGENCE OF GRASS OR BRUSH SPECIES? NUTRIENTS,PLANTING,COMPETITION

518. 07 674 WHAT IS THE SUCCESSIONAL PATTERN AND TIME OF REGROWTH AFTER COMPLETE OR PARTIAL REMOVAL OF OVERSTORY AND/OR UNDERSTORY, A) BY FIRE, B) BY MECHANICAL MEANS? SUCCESSION,MANIPULATION COMPARISON,CONIFEROUS FOREST,SHRUB UNDERSTORY,HERBAGE UNDERSTORY,REPRODUCTION

519. 07 725 THE EXCLUSION OF GROUND FIRES WITHIN THE NORTHERN CALIFORNIA DISTRICT HAS BROUGHT ABOUT A FOUR SIDED PROBLEM: A) ALLOWED DENSE STANDS OF HARDWOOD BRUSH AND UNDESIRABLE "WEED" TREES TO DEVELOP UNDER THE OLD GROWTH DOUGLAS-FIR TREES. THIS HAS EFFECTIVELY ELIMINATED THE ESTABLISHMENT OF CONIFER REPRODUCTION IN MANY AREAS. B) ALLOWED BRUSH AND WEED TREES TO GROW OUT OF THE REACH OF THE BLACK TAILED DEER RESULTING IN FEWER DEER, DUE TO LACK OF BROWSE. C) RESULTED IN AN IMPENETRABLE WALL OF VEGETATION, PREVENTING ACCESS TO BOTH MAN AND LARGE GAME ANIMALS. D) THIS RESULTING HEAVY STAND OF UNDERBRUSH INCREASES THE DANGER OF AN INTENSE BURN WHICH WILL

DESTROY THE SITE-BOTH VEGETATION AND SOIL. IF PRESCRIBED GROUND FIRE IS ONE POSSIBLE TREATMENT FOR THESE CONDITIONS, WHAT MIGHT BE THE EFFECT OF VARIOUS SEASONS (SOIL AND FUEL MOISTURE) OF BURNING, AND FREQUENCY OF PRESCRIBED GROUND FIRES, AS SEEN IN CONIFER REPRODUCTIVE SUCCESS, DEER POPULATION DENSITY, GAME ANIMAL ACCESS, AND REMAINING FUEL QUANTITY? FIRE EXCLUSION,FIRE FREQUENCY,TIMING,REPRODUCTION,GAME ANIMAL,FUEL/BIOMASS ACCUMULATION,PRESCRIBED FIRE

520. 07 747 WHAT IS THE AVERAGE TIME THAT A FIRE KILLED SNAG WILL STAND BEFORE NATURE TAKES ITS COURSE AND IT FALLS DOWN BY ITSELF? (BASED ON DIAMETERS, OF COURSE) SNAG,AGE,SIZE CLASS,DECOMPOSITION

521. 07 747 WHAT IS THE EFFECT OF FIRE INTENSITY ON FUTURE CONE PRODUCTION? DOES AN INCREASE IN SEED PRODUCTION RESULT ON SURVIVING TREES? SEED,FIRE INTENSITY

522. 07 747 WHAT IS THE EFFECT OF FIRES OF VARIOUS INTENSITIES, AND AT DIFFERENT TIMES OF THE YEAR, ON THE SEEDS OF ANNUAL GRASSES AND OTHER ANNUALS? FIRE INTENSITY,TIMING,SEED,GRASSLAND

523. 07 748 ASSUME NO RAIN FROM MAY TO SEPTEMBER, IN STEEP MOUNTAINOUS TERRAIN: WHAT MIGHT BE THE COMPARATIVE EFFECTS BETWEEN (1) CRUSHING SLASH INTO CUTOVER SLOPES, VS. (2) PILING AND BURNING SLASH, WITH REGARD TO SEEDLING GROWTH AND PRODUCTION? WOULD SOIL EROSION DIFFER WITH THESE CONTRASTING TREATMENTS? MANIPULATION COMPARISON,REPRODUCTION,VEGETATION,SOIL EROSION

524. 07 748 ASSUME NO RAIN FROM MAY TO SEPTEMBER, IN STEEP MOUNTAINOUS TERRAIN: WHAT MIGHT BE THE EFFECT OF VARIOUS DEGREES OF LOGGING SLASH REDUCTION BY BURNING, ON THE WIND DESSICATION OF SUBSEQUENT SEEDLINGS AND THE SUPPLY OF LIGHT, NUTRIENTS, MOISTURE AND HEAT TO THE SEEDLINGS? HOW WOULD THIS VARY WITH SLOPE? FUEL REDUCTION,MICROCLIMATE,REPRODUCTION,NUTRIENTS,TOPOGRAPHY ,VEGETATION

525. 07 749 WHAT EFFECT DO REPEATED FIRES HAVE ON THE REGENERATION OF POISON OAK IN THE SIERRA NEVADA FOOTHILLS? WHAT IS THE PALATABILITY OF POISON OAK COMPARED TO ASSOCIATED SPECIES? FIRE FREQUENCY,HERBAGE UNDERSTORY,REPRODUCTION,ORGANISM,HERBIVORY,DOMESTIC LIVESTOCK

526. 07 749 WHEN IS THE MOST OPPORTUNE TIME TO REMOVE BRUSH GROUND COVER FOR A FUEL BREAK SO THAT REGENERATION IS MINIMIZED, DURING EARLY SPRING BEFORE INITIAL GROWTH STARTS, OR LATE FALL AFTER GROWTH HAS TERMINATED FOR THE SEASON? GENERAL FIRE MANAGEMENT,SHRUBLAND,REPRODUCTION,COMMUNITY,TIMING

527. 07 750 WHAT IS THE DIFFERENCE IN THE EFFECT OF SPRING FIRES AND FALL FIRES AS FAR AS DAMAGE TO SAPLING, POLE AND LARGER STANDS? IS THERE A DIFFERENCE BETWEEN REACTION OF CONIFERS AND HARDWOODS? TIMING,HEAT EFFECTS,MORTALITY,SIZE CLASS

528. 07 750 WHAT IS THE EFFECT OF REPEATED (EVERY TWO YEARS) GROUND FIRES THRU HAZEL BRUSH UNDERSTORY, IN MIXED HARDWOOD DOUGLAS-FIR STANDS? WILL HAZEL CONTINUE TO SURVIVE, AND WILL THERE BE ANY DETRIMENTAL EFFECTS ON OVERSTORY? GROUND FIRE,FIRE FREQUENCY,SHRUB UNDERSTORY,PRODUCTIVITY

529. 07 750 WILL BURNING OF PILED BRUSH AND LOGS STERILIZE SOIL IN VICINITY OF THE PILE AND IF SO FOR HOW LONG? FIRE INTENSITY,SOIL,PRESCRIBED FIRE,FUEL REDUCTION,MICROORGANISM

530. 07 750 WOULD PRESCRIBED BURNING (SURFACE FIRE ONLY, PRIOR TO CUTTING), IN DOUGLAS-FIR STANDS, CHANGE THE SOIL AND WATERSHED CHARACTERISTICS TO THE POINT THAT REGENERATION WOULD BE AFFECTED? REPRODUCTION,SOIL,PRESCRIBED FIRE

531. 07 820 WHAT EFFECT DO LIGHT GROUND FIRES AT 3-5 YEAR INTERVALS HAVE ON GROWTH RATES OF EVEN AGED PONDEROSA PINE POLE AND YOUNG SAW TIMBER STANDS WHEN COMPETING VEGETATION IS NOT A FACTOR? FIRE FREQUENCY,GROUND FIRE,PRODUCTIVITY

532. 07 820 WHAT EFFECT DO REPEATED (3-5 YEAR INTERVALS) LIGHT GROUND FIRES HAVE ON AVAILABLE SOIL NUTRIENTS IN PONDEROSA PINE STANDS? FIRE FREQUENCY,GROUND FIRE,NUTRIENTS

533. 07 821 IN REGARD TO GROUND SURFACE TEMPERATURES AND THE GENERAL MICROCLIMATE NEEDED FOR WHITE PINE AND WHITE FIR REGENERATION, HOW DO CLEAR-CUT AREAS (WHERE SLASH IS LOPPED) COMPARE WITH LIKE AREAS THAT HAVE BEEN BURNED? REPRODUCTION,MANIPULATION COMPARISON,MICROCLIMATE

534. 07 821 IS THE USE OF LIGHT GROUND FIRES (IN CONNECTION WITH THINNING), IN DENSE AND EVEN-AGED FIR STANDS, DETRIMENTAL TO MARTEN AND FISHER POPULATIONS? GROUND FIRE,SMALL MAMMAL,DENSITY

535. 07 821 TO WHAT EXTENT DOES THE EXCLUSION OF GROUND FIRES FROM MEADOW LANDS (ELEVATION 5000-7000 FT.) PROMOTE LODGEPOLE PINE AND RED ALDER ENCROACHMENT ON NATURAL GRASS COVER? FIRE EXCLUSION,GROUND FIRE,SUCCESSION,GRASSLAND

536. 07 822 IN DECREASING THE NATURAL FIRE FREQUENCY, WILL LARGE CONCENTRATIONS OF NUTRIENTS BECOME LOCKED-UP IN LITTER AND SLASH AND THEREBY REDUCE TREE GROWTH? FIRE FREQUENCY,NUTRIENTS,LITTER,PRODUCTIVITY

537. 07 822 WHAT IS THE EFFECT OF DECREASING THE NATURAL FIRE FREQUENCY AS SEEN IN LITTER ACCUMULATION; DO RATES OF DECOMPOSITION CHANGE AS DEPTHS INCREASE? FIRE FREQUENCY,LITTER,DECOMPOSITION

538. 07 822 WHAT IS THE EFFECT OF DECREASING THE NATURAL FIRE FREQUENCY AS SEEN IN THE FREQUENCY, DISTRIBUTION AND ABUNDANCE OF ROOT ROT DISEASES OF CONIFERS? FIRE FREQUENCY,DISEASE

539. 07 822 WHAT TYPE OF LOGGING SYSTEM, AND FOLLOW-UP TREATMENT, WOULD NOW MOST LIKELY DUPLICATE THE EFFECTS OF PERIODIC NATURAL FIRES? MANIPULATION COMPARISON,FIRE FREQUENCY

540. 07 822 WITH A DECREASE IN THE NATURAL FIRE FREQUENCY OVER LARGE REGIONS, IS THERE A POSSIBILITY OF CERTAIN RARE PIONEER PLANT SPECIES BECOMING EXTINCT DUE TO THE GRADUAL ATTRITION OF VIABLE SEED SOURCES? FIRE FREQUENCY,SEED,REPRODUCTION

541. 08 510 WHAT IS THE EFFECT OF CHANGING THE SEASONAL TIMING AND REBURN FREQUENCY AS SEEN IN THE DOMINANT POST-FIRE PLANT SPECIES IN PINYON-JUNIPER INVADED SAGEBRUSH COMMUNITIES? TIMING,FIRE FREQUENCY,COMPETITION,SUCCESSION

542. 09 514 FIRE HAS CREATED THOUSANDS OF ACRES OF THICK SUPPRESSED STANDS OF LODGEPOLE PINE DUE TO THIS SPECIES' SEROTINOUS CONE NATURE. THEREFORE FIRE SHOULD BE CAREFULLY CONTROLLED IN LPP TO PREVENT REGENERATION OF THICK STANDS. IS THIS A VALID OBSERVATION? SEED,FIRE EFFECTS,POPULATION,PRESCRIBED FIRE,FIRE EXCLUSION,GROWTH,REPRODUCTION,COMPETITION,POPULATION,PRESCRIBED FIRE,FIRE EXCLUSION

543. 09 515 TO WHAT EXTENT DOES FIRE CHANGE THE SUSCEPTIBILITY OF INTERMOUNTAIN CONIFEROUS TREES TO INVASION BY FUNGI THROUGH FIRE SCARS? STEM,FIRE EFFECTS,DISEASE,CONIFEROUS FOREST

544. 09 518 DOES THE PRESENCE OF MANY SMALL FIRES IN AN AREA CAUSE WILDLIFE TO LEAVE THE AREA? ANIMAL BEHAVIOR,MOSAIC,WILDLIFE,FIRE DENSITY

545. 09 518 WHAT FACTORS CONTRIBUTE TO GROUND FUEL BUILD-UP IN AN AREA THAT HASN'T ANY HISTORY OF HEAVY GROUND FUEL? FUEL/BIOMASS ACCUMULATION

546. 09 519 ARE MEADOW LANDS AND NATURAL FORAGE AREAS GRADUALLY ENCROACHED UPON BY CONIFEROUS FOREST UNDER FIRE PROTECTION? FIRE EXCLUSION,CONIFEROUS FOREST,GRASSLAND,COMPETITION

547. 09 520 BECAUSE WE ARE CONTROLLING WILD LAND FIRES, WATERSHED CONDITIONS ARE BETTER IN THE UPSTREAM WATERSHED GENERALLY. STABILIZATION OF THE STREAMBEDS ARE RESULTING FROM THE EXCLUSION OF FIRE. BUT, WILLOW PATCHES THRIVE ON DISTURBED STREAM CHANNELS. THUS WILDFIRE IN THE UPLAND WATERSHEDS MAY HAVE SOME VALUE IN MAINTAINING THE WILLOW PATCHES FOR MOOSE POPULATIONS. IS THIS A FACT OR CAN NATURAL GEOLOGIC AND NATURAL RUNOFF CONDITIONS BE FREQUENT ENOUGH TO MAINTAIN MOOSE HABITAT? WATERSHED,FIRE EFFECTS,FIRE EXCLUSION,GAME ANIMAL,POPULATION,STREAM

548. 09 520 IS THERE RESEARCH ON THE PRESCRIPTION OF "GENTLE" BURNINGS? I THINK IT IS GENERALLY RECOGNIZED THAT PROPERLY CONTROLLED BURNING IS ESSENTIAL TECHNOLOGY IN

MANAGING MANY KINDS OF VEGETATION. WITH REGARD TO GENTLE BURNINGS, WHAT IS A GENTLE BURN IN RELATIONSHIP TO FIRE INTENSITY, RATE OF SPREAD, FIRE SIZE, AND FREQUENCY? PRESCRIBED FIRE,FIRE INTENSITY,FIRE BEHAVIOR,AREA SIZE,TIMING,GENERAL FIRE MANAGEMENT

549. 09 520 IT HAS BEEN SPECULATED THAT FIRE EXCLUSION IN MANY OF OUR CONIFEROUS FOREST TYPES IS A LIMITING FACTOR ON ELK POPULATIONS OR OTHER GAME POPULATIONS AND HABITAT. WILL FIRE EXCLUSION LIMIT OR REDUCE GAME POPULATIONS? QUANTITATIVE MEASUREMENT IS NEEDED ON THIS SUPPOSITION. FIRE EXCLUSION,GAME ANIMAL,POPULATION GROWTH,COMMUNITY

550. 09 521 ALONG THE WASATCH FRONT IN NORTHERN UTAH PREVENTION AND INITIAL ATTACK ARE GIVEN EXTREME EMPHASIS, BECAUSE THESE LANDS ARE ALL KEY MUNICIPAL WATERSHEDS. A QUESTION WE OFTEN ASK OURSELVES IS "WILL THIS PRACTICE OF FIRE EXCLUSION SOMETIME IN THE FUTURE HAVE AN ADVERSE EFFECT EXCEEDING THE BENEFITS OF A QUALITY AND QUANTITY WATER SUPPLY"? FIRE EXCLUSION,WATERSHED,CONIFEROUS FOREST

551. 09 521 WHILE IT IS BECOMING MORE UNIVERSALLY ACCEPTED THAT FIRE DOES AND CAN PLAY AN IMPORTANT ROLE IN FOREST LAND MANAGEMENT: IT IS STILL DIFFICULT TO SELL TO THE DECISION MAKERS IN MANY CASES. THE REASONS IT SEEMS ARE THAT RESEARCH RESULTS IN FREE-FIRE ZONES AND PRESCRIBED BURNING ARE NOT GETTING TO THE ADMINISTRATORS. ANSWERS TO THE FOLLOWING MIGHT HELP IN GIVING THE LAND MANAGERS A BETTER UNDERSTANDING AND AID IN THE DECISION MAKING PROCESS: WHAT ARE THE TRADE OFFS IN FREE-FIRE ZONES AND PRESCRIBED BURNING BOTH MONETARILY AND FROM A RESOURCE STANDPOINT? WHAT ARE THE SAVINGS TO THE TAX PAYER IN ESTABLISHING FREE-FIRE ZONES IN TERMS OF REDUCED MANPOWER AND DOLLARS IN PREVENTION, DETECTION, AND INITIAL ATTACK? DO WE KNOW WHAT THE BENEFITS ARE IN QUALITATIVE AND QUANTITATIVE TERMS TO WILDLIFE INCLUDING THE SMALL BIRDS AND MAMMALS? HOW DO WE DEAL WITH PUBLIC OPINION WITH REGARD TO THE SMOKEY BEAR SYNDROME, OF "PUT THEM ALL OUT AT ANY COST"?. AND ALSO FROM A SOCIOLOGICAL STANDPOINT, DO WE NEGATE ANY OF OUR PREVENTION EFFORTS OF THE PAST IN ESTABLISHING FREE-FIRE ZONES? FIRE EXCLUSION,FIRE EFFECTS,ECONOMIC EFFECTS,GENERAL FIRE MANAGEMENT,PRESCRIBED FIRE,WILDLIFE,SMALL MAMMAL,BIRD,ECOSYSTEM

552. 09 522 HOW WOULD INTENSE FIRE AFFECT MORTAR IN ARCHEOLOGICAL RUINS? WOULD STABILITY OF STANDING WALLS BE WEAKENED? HUMAN ECOLOGY,FIRE EFFECTS,HEAT EFFECTS,AESTHETICS

553. 09 522 ON AN INTENSE CROWN FIRE, WHAT EFFECT IN TREE WEAKENING CAN BE EXPECTED AT THE FIRE EDGE? FIRE EFFECTS,AREA SIZE,MORTALITY,CROWN BURN

554. 09 523 MY FIRE EXPERIENCE HAS BEEN LIMITED TO SMALL FIRES IN THE PINYON-JUNIPER AND SAGEBRUSH TYPES SO MY QUESTIONS ARE ABOUT THE EFFECTS OF FIRES IN THESE TYPES. DOES A FIRE IN THE PINYON-JUNIPER TYPE HAVE ENOUGH IMPACT ON THE ENVIRONMENT TO WARRANT SUPPRESSION?

BECAUSE OF THE LACK OF GROUND COVER UNDER PINYON IS THE IMPACT FROM THE HEAT OF THE FIRE SUFFICIENT TO CAUSE DAMAGE TO THE SOIL? IS THE CONVERSION FROM PINYON TO GRASS AFTER A FIRE BENEFICIAL? SHOULD IT BE ENCOURAGED? TO WHAT EXTENT, IF AT ALL, IS THE WATERSHED AFFECTED BY THE REMOVAL OF PINYON? HOW MANY ACRES OF PINYON WOULD HAVE TO BE INVOLVED IN A FIRE BEFORE ANIMAL LIFE WOULD BE SERIOUSLY AFFECTED? CAN THE EFFECTS OF FIRE ON SOIL AND WILDLIFE IN THIS TYPE BE COMPARED TO A CHAINING PROJECT? FIRE EFFECTS,FIRE EXCLUSION,COMPETITION,SUCCESSION,GRASSLAND,WATERSHED,AREA SIZE,WILDLIFE,SOIL,MANIPULATION COMPARISON,ECOSYSTEM

555. 09 730 WHAT IS THE EFFECT OF FIRE SUPPRESSION ON PINYON-JUNIPER INVASION OF A GIVEN AREA? WHAT IS THE EFFECT OF UNSUPPRESSED WILDFIRES IN GRASS-BRUSH ASSOCIATIONS IN RELATION TO ASSOCIATED WILDLIFE? WHAT CHANGES OCCUR IN SMALL MAMMAL AND SMALL BIRD POPULATIONS IN CONTROLLED BURNS OF BRUSHLAND? CAN MANAGEMENT FOR ANNUAL GRASSES BE DONE SUCCESSFULLY WITH FIRE? FIRE EXCLUSION,FIRE EFFECTS,COMPETITION,WILDLIFE,CONIFEROUS FOREST,SHRUBLAND,GRASSLAND,SMALL MAMMAL,BIRD,PRESCRIBED FIRE,ECOSYSTEM

556. 09 731 DOES WILDFIRE NORMALLY TAKE PLACE UNDER CONDITIONS WHEN THE CLEARING INDEX (AIR POLLUTION CONTROL) IS FAVORABLE FOR BURNING? WHAT IS THE "PUBLIC'S" OPINION OF VIEWING A BURNED PINON-JUNIPER STAND FROM AN AESTHETICS POINT OF VIEW? TIMING,MICROCLIMATE,AIR POLLUTION,PUBLIC REACTION,AESTHETICS,CONIFEROUS FOREST,VALUE JUDGEMENT

557. 09 731 WE ARE LOCATED IN A PINON-JUNIPER TYPE TIMBER AREA. THEREFORE, OUR NEEDS HERE ARE IN CONNECTION WITH THAT TYPE RATHER THAN THE COMMERCIAL TIMBER STANDS. WE HAVE CONSIDERABLE PROBLEMS WITH LIGHTNING STRIKES INVOLVING FIRE IN 1 OR 2 TREES. OUR CONCERNS ARE FOR THE NEED FROM AN ECOLOGICAL STANDPOINT - HOW IMPORTANT IS IT TO TAKE ACTION ON EACH FIRE? WHAT EFFECT DOES A WILDFIRE ON AN AREA HAVING 60%+ CANOPY COVER HAVE ON SOIL TEMPERTURE, SOIL EROSION POTENTIAL, SOIL STERILIZATION, ETC? NORMALLY IN THIS AREA 60% CANOPY WILL REDUCE THE UNDERSTORY TO A POINT IT WILL NOT CARRY A GROUND FIRE. WHAT EFFECT DOES FIRE HAVE IN A PINON-JUNIPER STAND ON THE MINOR WILDLIFE SPECIES (RABBITS, SONG BIRDS, ETC.) HABITAT? BY ALLOWING A FIRE TO BURN DO WE ELIMINATE THESE SPECIES? FIRE EFFECTS,LIGHTNING-CAUSED FIRE,SMALL MAMMAL,BIRD,SOIL,HEAT EFFECTS,CROWN,GROUND FIRE

558. 10 069 DOES NUTRIENT ENRICHMENT OF STREAMS AFFECT COLIFORM LEVELS? NUTRIENTS,STREAM,MICROORGANISM

559. 10 069 WHAT MIGHT BE THE EFFECT OF VARIOUS DEGREES OF LITTER AND VEGETATION REDUCTION AS SEEN IN THE WATER BALANCE, STREAM FLOW PLUS SOIL WATER BALANCE? FUEL REDUCTION,HYDROLOGY

560. 10 070 HOW CAN FIRE BE USED TO PRODUCE A NORMALLY STOCKED STAND FROM A DOGHAIR LODGEPOLE PINE STAND? DENSITY,POPULATION

561. 10 070 HOW DO PEOPLE OF VARIOUS TYPES PERCEIVE THE IDEA OF FIRE, EITHER MAN-CAUSED, PRESCRIBED, OR NATURAL, IN THEIR VALUE SYSTEM? SOCIAL EFFECTS

562. 10 070 HOW IS FIRE RELATED TO THE PRODUCTION OF FIREWOOD IN RECREATIONAL AREAS? RECREATION,FUEL/BIOMASS ACCUMULATION

563. 10 070 HOW WELL CAN PEOPLE OF VARIOUS OCCUPATIONS IDENTIFY EVIDENCES THAT A FOREST HAS BURNED AT VARYING LENGTHS OF TIME AGO? SOCIAL EFFECTS

564. 10 071 CAN THE RATE OF NUTRIENT RELEASE RESULTING FROM FOREST BURNING BE RELATED TO SUCH FIRE CHARACTERISTICS AS FIRE FREQUENCY, INTENSITY, OR RATE OF SPREAD? NUTRIENTS,FIRE FREQUENCY,FIRE INTENSITY

565. 10 071 FOLLOWING A HOT FIRE, WHAT IS THE ULTIMATE FATE OF THE RICH LAYER OF NUTRIENTS LYING ON THE SOIL SURFACE IN THE FORM OF ASH IN LODGEPOLE PINE ECOSYSTEMS? FIRE INTENSITY,ASH,NUTRIENTS

566. 10 071 FOLLOWING FOREST BURNING, MIGHT SOIL NITROGEN LOSSES BE COMPENSATED BY HIGHER SOIL TEMPERATURES IN A SORT OF TRADE-OFF, RESULTING IN AN IMPROVEMENT OF SITE CONDITIONS FOR TREE GROWTH? PRODUCTIVITY,NUTRIENTS,MICROCLIMATE

567. 10 071 IN AREAS WHERE LOGGING IS USUALLY FOLLOWED BY BROADCAST BURNING, WHAT SPECIFIC CHANGES IN SOIL PROPERTIES (BOTH CHEMICAL AND PHYSICAL) MIGHT RESULT FROM FIRE? FUEL REDUCTION,SOIL

568. 10 071 IN CERTAIN FOREST SYSTEMS, IS IT DESIRABLE TO CONTROL THE SEVERITY OF BURN (I.E., ONLY PART OF THE LITTER CONSUMED) IN ORDER TO REDUCE EXTREME PH AND/OR C.E.C. CHANGES? CAN THESE CHANGES BE IDENTIFIED AND RELATED TO CERTAIN SOIL OR FOREST TYPES? FUEL REDUCTION,NUTRIENTS

569. 10 071 WHAT EFFECT DOES FIRE HAVE ON SOIL MICROORGANISM POPULATIONS, ESPECIALLY MYCORRHIZAL FUNGI WHICH MIGHT BE QUITE IMPORTANT IN TREE SEEDLING ESTABLISHMENT? FUNGUS,ROOTS,REPRODUCTION

570. 10 071 WHAT IS THE EFFECT OF A FOREST FIRE ON THE WATER QUALITY FROM A BURNT AREA, ESPECIALLY WHEN THE FIRE IS INTENSE AND LIMITS ESTABLISHMENT OF SUBSEQUENT PLANT COVER? HYDROLOGY,NUTRIENTS

571. 10 077 A QUESTION ARISING FROM FIRE SUPPRESSION CONCERNS THE PRESENT UPPER ELEVATIONAL LIMIT OF TREE GROWTH. WITH REDUCED FIRE INCIDENCE, HOW CAN THIS BE EXPECTED TO RESPOND? WILL IT REMAIN STATIONARY OR WILL MOVEMENT UPWARD ENSUE? FIRE FREQUENCY,ZONATION,ECOTONE

572. 10 077 WHAT ARE HYDROLOGIC CONSEQUENCES OF BURNING ON SNOW DISTRIBUTION AND REDISTRIBUTION, EFFECTS ON SNOW MELT PATTERNS AND STREAM FLOW? FIRE CLOSE TO TIMBERLINE WOULD SEEM CAPABLE OF INDUCING MARKED CHANGES IN SNOW DISTRIBUTION AND MELT BY INTRODUCING AN ALPINE ENVIRONMENT AT SUB ALPINE ALTITUDES. IS THIS SUFFICIENT TO CAUSE SIGNIFICANT HYDROLOGIC RESPONSES? SNOW,HYDROLOGY,ZONATION,MOUNTAIN

573. 10 079 CATALOG OF FIRE-TYPE VEGETATION IN THE COLORADO ROCKY MOUNTAINS FROM VARIOUS ELEVATIONS-E.G: PRAIRIE, MONTANE, SUB-ALPINE AND ALPINE. EXPERIMENT ORIENTED QUESTION,FIRE FREQUENCY,FUEL/BIOMASS ACCUMULATION

574. 10 079 WHAT IS THE RELATIONSHIP BETWEEN FIRE AND TIMBERLINE IN THE NORTH AMERICAN ROCKY MOUNTAIN ALPINE, AND AT THE FOREST-SHORT GRASS PRAIRIE ECOTONE? MOUNTAIN,ECOTONE,ZONATION

575. 10 191 AS MANY ASPEN STANDS REVERT TO THE CONIFEROUS TYPES, WILL FIRE SUPPRESSION AND EXCLUSION DIMINISH THE TOTAL AREA NOW COVERED WITH ASPEN? AREA SIZE,SUCCESSION,FIRE EXCLUSION,DECIDUOUS FOREST

576. 10 191 IS FIRE EXCLUSION RESPONSIBLE FOR THE TWO AND THREE-STORIED DENSE ASPEN STANDS USUALLY FOUND IN THE YOUNGER STANDS OF 100+ YEARS? IF SO, HOW WILL THESE STANDS DIFFER IN THE FUTURE COMPARED WITH THE OLDER STANDS OF TODAY WHICH HAVE EXPERIENCED GROUND FIRES? DENSITY,GROUND FIRE,AGE,DECIDUOUS FOREST

577. 10 191 MANY OPEN, OVERMATURE ASPEN STANDS, WITHOUT A CONIFEROUS UNDERSTORY, FAIL TO PRODUCE SUCKERS. DOES FIRE EXCLUSION PREVENT ASPEN SUCKERING IN THESE OLD STANDS, AND WILL THESE STANDS REVERT TO GRASS LAND OR SHRUBS ONCE THE OVERSTORY IS GONE? REPRODUCTION,SUCCESSION,FIRE EXCLUSION,AGE,DECIDUOUS FOREST

578. 10 192 DO LARGE INSECT OUTBREAKS IN ENGELMANN SPRUCE, LODGEPOLE PINE AND PONDEROSA PINE INCREASE FIRE HAZARD? IF SO, WHAT TERMS DO WE ACTUALLY HAVE TO EVALUATE HAZARD INCREASE? FOR HOW LONG IS HAZARD INCREASED? CAN AN INCREASE BE EQUATED TO DOLLAR EXPENDITURES THAT SHOULD BE SUBTRACTED FROM INSECT CONTROL COSTS? INSECT,FUEL/BIOMASS ACCUMULATION,ECONOMIC EFFECTS

579. 10 193 UNDER WHAT CONDITIONS IS CONTROLLED BURNING LIKELY TO BE A SATISFACTORY MEANS FOR: A) PREVENTING OR REDUCING EXCESSIVE BUILDUP OF FOREST FUELS, B) MAINTAINING FIRE-DEPENDENT FOREST TYPES? FUEL/BIOMASS ACCUMULATION

580. 10 193 UNDER WHAT CONDITIONS, IF ANY, IS CONTROLLED BURNING AN EFFECTIVE MEANS FOR CONTROLLING SPRUCE BARK BEETLE POPULATIONS? PRESCRIBED FIRE,INSECT

581. 10 275 WHAT MIGHT BE THE EFFECT OF CHANGING THE AREAL PROPORTION AND SPATIAL LOCATION OF BURNED, OPEN AREA WINTER RANGE VS. DENSE-UNBURNED CONIFER STANDS, AS SEEN IN THE POPULATION DENSITIES OF BIG GAME ANIMALS? AREA SIZE,MOSAIC,SHRUBLAND,DENSITY,POPULATION GROWTH,GAME ANIMAL

582. 10 283 HOW IS MACRO-INVERTEBRATE SPECIES DIVERSITY IN STREAMS AFFECTED BY FIRE ON THE WATERSHED? WHAT CONTROLS THE RECOVERY RATE? STREAM,ARTHROPODS,SPECIES DIVERSITY,TIMING

583. 10 283 HOW LONG DOES IT TAKE FOR PRE-FIRE NUTRIENT LEVELS TO BECOME RE-ESTABLISHED IN THESE STREAMS? STREAM,NUTRIENTS,TIMING

584. 10 283 UNDER WHAT CONDITIONS DO FIRES RESULT IN INCREASES OR DECREASES IN PRIMARY PRODUCTION IN STREAMS DRAINING THE BURNED AREAS? STREAM,PRODUCTIVITY

585. 10 283 WHAT ARE THE NUTRIENT LEVELS IN STREAMS DRAINING BURNED WATERSHEDS? STREAM,NUTRIENTS,TIMING

586. 10 284 HOW CAN FIRE BE USED TO ENHANCE THE RANGE OF BIGHORN SHEEP--OPEN AREAS IN RELATION TO ESCAPE COVER? IMPROVING FORAGE CONDITIONS? RANGE SANITATION (EFFECTS ON PARASITES AND INTERMEDIATE HOSTS)? GAME ANIMAL

587. 10 306 IS DUFF AND HUMUS REMAINING AFTER FIRE A GOOD INDICATION OF INTENSITY? DUFF,FIRE INTENSITY,FUEL REDUCTION

588. 10 306 WHAT FREQUENCY OF BURNING OF PONDEROSA PINE RESULTS IN OPEN STANDS, WITH GRASS OR SHRUB UNDERSTORY? WHAT OTHER FACTORS MAY AFFECT UNDERSTORY RESPONSE? FIRE FREQUENCY,HERBAGE UNDERSTORY,SHRUB UNDERSTORY,DENSITY,COMMUNITY,VEGETATION

589. 10 306 WHAT SPECIES OF PLANT SEED CAN BE EXPECTED TO SURVIVE FIRE AND IN WHAT GROUND LAYERS RELATED TO FIRE INTENSITY? EXPERIMENT ORIENTED QUESTION,SEED,HEAT EFFECTS,FIRE INTENSITY

590. 10 524 AFTER A FIRE THE BURN IS USUALLY PLANTED TO GRASS IMMEDIATELY TO STABILIZE THE SOIL. HAVE THERE BEEN STUDIES DONE ON HOW THIS GRASS STAND AFFECTS CHANCES OF GETTING A TIMBER STAND RE-ESTABLISHED? SOIL EROSION,COMPETITION,MANIPULATION COMPARISON

591. 10 526 BECAUSE OF ADVERSE PUBLIC REACTION TO SLASH BURNING, ATTEMPTS HAVE BEEN MADE TO BURN AT HIGHER TEMPERATURES AND THUS REDUCE PARTICULATE PRODUCTS. GASEOUS PRODUCTS ARE THEREBY INCREASED. ARE THESE GASES MORE HARMFUL TO HEALTH AND ENVIRONMENT THAN THE ORIGINAL SMOKE PARTICLES? PUBLIC REACTION,HUMAN ECOLOGY,AIR POLLUTION,MANIPULATION COMPARISON,VALUE JUDGEMENT,PRESCRIBED FIRE

592. 10 526 HOW SHOULD SEED BE PLANTED ON A BURNED OUT AREA? IS THE SOIL STERILE? HOW ABOUT EXCESSIVE HEAT AND DRYING OUT DUE TO BLACK COLOR? WOULD A STRAW MULCH HELP? SEED,CHARCOAL,ASH,MICROCLIMATE,MANIPULATION COMPARISON,REPRODUCTION,SOIL

593. 10 526 WHAT ARE THE ALTERNATIVES TO PRESCRIBED BURNING THAT WILL PROVIDE THE NECESSARY PH, MINERALS, NUTRIENTS,ETC. FOR FUTURE ECOSYSTEM CONTINUATION? WILL REMOVAL OF LOGGING SLASH AND NATURAL SLASH IMPERIL THE NATURAL ABILITY OF THE FOREST TO PERPETUATE ITSELF IN A HEALTHY MANNER? FIRE EXCLUSION,PRESCRIBED FIRE,PH,NUTRIENTS,HUMAN DISTURBANCE,ECOSYSTEM

594. 10 526 WHAT EFFECT DOES A HEAVY SNOWPACK HAVE ON AN EXTENSIVELY BURNED AREA WHICH HAS BEEN SEEDED THE PRECEEDING SUMMER? HOW CAN ANY ADVERSE EFFECTS, IF ANY ARE CREATED, BE PREVENTED? SNOW,SOIL-WATER RELATIONS,SEED,REPRODUCTION

595. 10 530 ARE RED SOILS FOLLOWING BURNING IN THE COLORADO ROCKIES INDICATIVE OF STERILIZATION? AT WHAT TEMPERATURE DO THE ORGANIC MATTER AND SOIL FAUNA WITHIN THE TOP INCH OF SOIL BECOME DESTROYED? WHAT ARE THE MAXIMUM SOIL SURFACE TEMPERATURES DURING BURNING AS AFFECTED BY VARIABLES OF SLOPE, DEPTH OF SLASH, FUEL TYPES? WHAT ARE THE INSULATION QUALITIES OF BARK? E.G. CAMBIUM CANNOT BE DESTROYED AT TEMPERATURES OF "X" DEGREES IF PINE BARK IS "Y" INCHES THICK. WHAT ARE THE EFFECTS OF DIRECT SEEDING OF EITHER PONDEROSA PINE OR ENGELMANN SPRUCE INTO ASH FOLLOWING A FIRE? HOW MUCH FUEL MUST BE BURNED TO SIGNIFICANTLY INFLUENCE THE AMOUNT OF CO2 AND OTHER GASES IN OUR ATMOSPHERE? MICROCLIMATE,ORGAN,SOIL,FIRE EFFECTS,HEAT EFFECTS,STEM,CONIFEROUS FOREST,ASH,PLANTING

596. 10 530 I PERSONALLY BELIEVE THE LAND MANAGER COULD USE FIRE TO HIS ADVANTAGE IN TYPE CONVERSION, MAINTENANCE OF A TYPE, THINNING, FUEL REDUCTION, WILDLIFE HABITAT IMPROVEMENT. UNFORTUNATELY, WE (GENERALLY) LIVE UNDER A STIGMA THAT FIRE IS "BAD" WHILE WE COULD BE USING IT TO OUR ADVANTAGE DAILY. FIRE CAN BE USED TO THIN PONDEROSA PINE AS THEY DO WITH SOUTHERN PINES: HAS THERE BEEN RESEARCH PERFORMED IN THE ROCKIES CONCERNING THIS AND, IF NOT, WHY? CAN GROUND FIRES BE USED TO CONTROL MISTLETOE IN PONDEROSA PINE? WHAT INFLUENCE DO GROUND FIRES HAVE ON THE GERMINATION OF PONDEROSA PINE SEED? WHAT TEMPERATURES EXIST ON SOIL'S SURFACE FROM ABSORPTION OF SHORT-WAVE RADIATION FOLLOWING A BURN AND THE ASH IS BLACK? HOW SERIOUS ARE THE GASEOUS POLLUTANTS IN THE AIR FROM A BURN? EXAMPLE: 600 ACRES OF GREEN OAKBRUSH BURNED IN FOUR HOURS ON A CLEAR DAY WITH A 20 MPH WIND. FIRE EFFECTS,GROUND FIRE,SEED,REPRODUCTION,CONIFEROUS FOREST,MICROCLIMATE,ASH,CHARCOAL,AIR POLLUTION,SHRUB UNDERSTORY,FIRE EXCLUSION,DISEASE

597. 10 531 ENVIRONMENTALLY, WHAT DIFFERING EFFECTS OCCUR BETWEEN FIRES AND TIMBER HARVESTS - RECOGNIZING OF

COURSE DIFFERING DEGREES OF BURN AS WELL AS HARVEST METHODS? MANIPULATION COMPARISON,HUMAN DISTURBANCE,FIRE EFFECTS

598. 10 531 THERE IS INCREASING FEELING AMONG LAND MANAGERS THAT FIRES SHOULD BE ALLOWED TO BURN AS A NATURAL OCCURRENCE. WITH INCREASING HUMAN POPULATIONS AND ACCOMPANYING INCREASED RISK OF MAN-CAUSED FIRES, CAN WE AFFORD TO PERMIT UNCONTROLLED BURNING? HUMAN ECOLOGY,VALUE JUDGEMENT,MAN-CAUSED FIRE,FIRE EXCLUSION

599. 10 531 WITH INCREASING EMPHASIS ON "CLEANING-UP" AFTER TIMBER SALES WE ARE REQUIRED TO DO A MORE COMPLETE SLASH DISPOSAL JOB. HOW SERIOUS IS SLASH OR OTHER WOOD SMOKE POLLUTION? WE NEED BETTER ANSWERS. TODAY, WOOD SMOKE IS OFTEN CONSIDERED JUST AS "BAD" AS FACTORY OR AUTO POLLUTION. VALUE JUDGEMENT,FUEL REDUCTION,PUBLIC REACTION,AIR POLLUTION,PRESCRIBED FIRE

600. 10 533 WHAT EFFECT IS THE EXCLUSION OF FIRE HAVING ON NATURAL REGENERATION OF PONDEROSA PINE ON THE UNCOMPAHGRE PLATEAU OF COLORADO? WE HAVE AREAS OF HEAVY POLE STANDS OF PONDEROSA PINE THAT WERE ESTABLISHED 40 TO 70 YEARS AGO. SINCE THAT TIME THERE HAS BEEN ESSENTIALLY NO REGENERATION. WE DO HAVE HEAVY GRAZING IN SOME PINE STANDS, BUT WE ALSO HAVE SOME ISOLATED TRACTS THAT HAVE BEEN PROTECTED FROM GRAZING AND FIRE. WE STILL HAVE NO SIGNIFICANT NATURAL REGENERATION IN ANY OF THE STANDS. FIRE EXCLUSION,REPRODUCTION,POPULATION,HERBIVORY

601. 10 534 IN THE COLORADO ROCKIES, WHAT IS THE RELATIVE FREQUENCY OF LIGHTNING FIRE STARTING FROM HITS IN SNAGS AS COMPARED TO FIRES STARTED FROM HITS IN LIVE TREES? LIGHTNING-CAUSED FIRE,SNAG,FLAMMABILITY,CONIFEROUS FOREST,FIRE FREQUENCY

602. 10 535 AT WHAT LEVEL OF FIRE INTENSITY ARE ROOTS AND UNDERGROUND PARTS OF PLANTS DAMAGED OR DESTROYED FOR VARIOUS DEPTHS AND TYPES OF SOIL? FIRE INTENSITY,ROOTS,MORTALITY,SOIL

603. 10 535 CAN A SELECTED SPECIES, GENUS, OR FAMILY OF A PARTICULAR PLANT BE ERADICATED BY FIRE? IF SO, WHAT SPECIES, ETC. AND HOW SHOULD FIRE BE APPLIED AS A MANAGEMENT TOOL? GENERAL FIRE MANAGEMENT,VEGETATION,MORTALITY,SEED,ROOTS

604. 10 535 CAN FIRE BE USED AS AN EFFECTIVE WILDLIFE HABITAT MANAGEMENT TOOL--OR ARE THE BENEFITS IN TERMS OF BROWSE PRODUCED, AND AVAILABILITY, TOO SHORT IN TIME BEFORE ANOTHER BURN IS NEEDED, MAKING FIRE AN UNECONOMICAL WILDLIFE MANAGEMENT TOOL? HOW OFTEN WOULD YOU NEED TO BURN IN OAK BRUSH, ASPEN FOR BROWSE PRODUCTION ON A WINTER RANGE? SHRUBLAND,SUCCESSION,TIMING,PRESCRIBED FIRE,PRODUCTIVITY

605. 10 535 CAN THE LOSS OF SOIL NUTRIENTS BE CONTROLLED BY LIMITING THE SIZE OF SLASH PILES IN A CLEAR-CUT

PILE-AND-BURN OPERATION? NUTRIENTS,SOIL,FUEL REDUCTION,SIZE CLASS

606. 10 535 DOES FIRE HAVE AN EFFECT ON THE ERODIBILITY OF AN OTHERWISE STABLE SOIL? IF SO, AT WHAT LEVEL OF INTENSITY? FIRE INTENSITY,SOIL STRUCTURE,SOIL EROSION

607. 10 535 HOW MUCH HEAT CAN LODGEPOLE, SPRUCE OR FIR RECEIVE BEFORE DAMAGES OCCUR TO THE TREES INNER SYSTEM? SUCH AS LOSS OF ABILITY TO TRANSLOCATE WATER TO THE LIMBS? HEAT EFFECTS,MORTALITY,ORGANISM,STEM,ROOTS

608. 10 535 IN AN ASPEN-LODGEPOLE PINE STAND AFTER A FIRE--WHY DOES ASPEN BECOME THE DOMINANT? SUCCESSION,DECIDUOUS FOREST,CONIFEROUS FOREST

609. 10 535 WHAT NUTRIENTS ARE LOST FROM THE SOIL DUE TO A FIRE? HOW IS THE PRODUCTIVITY OF A SOIL AFFECTED BY A FIRE? NUTRIENTS,SOIL

610. 10 535 WHICH SPECIES, SPRUCE OR FIR, IS MOST APT TO REGENERATE NATURALLY IN THE SPRUCE-FIR FOREST OF COLORADO AFTER FIRE? REPRODUCTION,VEGETATION

611. 10 535 WILL SOIL FERTILIZING HELP IN ESTABLISHING PERMANENT VEGETATION AFTER AN AREA HAS SUFFERED AN INTENSE BURN? IF SO--WHAT ARE THE COST-BENEFIT RATIOS OF SUCH A PROGRAM? MANIPULATION COMPARISON,FIRE INTENSITY,NUTRIENTS,VEGETATION

612. 10 535 AFTER A FIRE, ARE INSECT POPULATIONS MORE APT TO RECOVER FASTER THAN RODENTS? INSECT,SMALL MAMMAL,POPULATION GROWTH

613. 10 536 ARE ALL LODGEPOLE PINE STANDS A RESULT OF PAST FIRE HISTORY? THE FRONT RANGE OF COLORADO HAS LODGEPOLE PINE STANDS WITH NON-SEROTINOUS OR STERILE CONES AND LITTLE EVIDENCE OF FIRE HISTORY. TO CLEARCUT OR BURN IN THESE STANDS RESULTS IN LITTLE OR NO REGENERATION. FIRE HISTORY,FIRE EFFECTS,REPRODUCTION,CONIFEROUS FOREST,SEED,POPULATION

614. 10 536 DO FREQUENT FIRES OF 10 ACRES AND OVER IN A FOREST AREA DISCOURAGE RESIDENTIAL DEVELOPMENTS WITHIN THAT FORESTED AREA? HUMAN ECOLOGY,FIRE FREQUENCY,AREA SIZE,PUBLIC REACTION

615. 10 536 DOES EXCLUDING FIRE FROM A CONIFEROUS FOREST CREATE CONDITIONS WHEREBY WHEN A FIRE DOES START IT SPREADS FASTER AND WILL MORE LIKELY BE LARGER IN SIZETHAN IN FORESTS WHERE NO PROTECTION EXISTS OR PRESCRIBED FIRES ARE COMMON? FIRE EXCLUSION,FIRE EFFECTS,FIRE BEHAVIOR,FUEL/BIOMASS ACCUMULATION,

616. 10 536 HAVE RESIDENTIAL DEVELOPMENTS IN FORESTED AREAS AFFECTED THE FREQUENCY OR SIZE OF MAN-CAUSED FIRES? HUMAN ECOLOGY,ECONOMIC EFFECTS,FIRE FREQUENCY,AREA SIZE,MAN-CAUSED FIRE

617. 10 536 IS FIRE EXCLUSION IN COLORADO ROCKY MOUNTAIN FORESTS AS CRITICAL FROM A FUEL BUILD-UP STANDPOINT AS ARE OTHER AREAS: I.E. WEST COAST, NORTHWEST FORESTS? FIRE EXCLUSION,FUEL/BIOMASS ACCUMULATION,MOUNTAIN,CONIFEROUS FOREST

618. 10 536 WHAT IS THE EFFECT OF HUMAN POPULATION ON FIRE OCCURRENCE? DO THE NUMBER OF FIRE STARTS DECREASE AS POPULATION INCREASES BECAUSE PEOPLE ARE WATCHING PEOPLE? HUMAN ECOLOGY,MAN-CAUSED FIRE,POPULATION GROWTH

619. 10 537 IS IT A MUST TO BURN LODGEPOLE CUT-OVER AREAS TO GET REPRODUCTION BY PROVIDING HEAT FOR CONE OPENING OR WILL HEATING OF THE SUN BE JUST AS GOOD? FIRE INTENSITY,MANIPULATION COMPARISON,REPRODUCTION,SEED,ORGAN,MICROCLIMATE,TOPOGRAPHY

620. 10 538 DOES OUR PRESENT METHOD OF SITE PREPARATION (PILING & BURNING, CHOPPING) ADEQUATELY SUBSTITUTE FOR A NATURAL FIRE OR NOT? ARE THE RESULTS SIMILAR IN CONNECTION WITH HERBACOUS VEGETATION, WILDLIFE HABITAT, EROSION, PERPETUATING SEROTINOUS CONES, SOIL NUTRIENTS AND PH? MANIPULATION COMPARISON,FIRE INTENSITY

621. 10 538 UNDER WHAT CONDITION (FUEL TYPE & AMOUNT, WIND, RH, TEMP., ETC.) CAN A GROUND FIRE (SAY A CONTROLLED BURN) GO THROUGH A STAND WITHOUT DAMAGE TO STANDING TREES OR AT LEAST A MINIMUM OF DAMAGE? FOR THE FUEL-TYPES AND AMOUNT, WHAT WOULD BE A SIMPLE METHOD OF DETERMINING THIS? GROUND FIRE,MORTALITY,VEGETATION

622. 10 539 WHAT IS THE RELATIONSHIP OF COMPACTNESS OF SLASH TO INTENSITY OF HEAT? FUEL REDUCTION,FIRE INTENSITY,FUEL/BIOMASS ACCUMULATION

623. 10 541 GENERALLY, MY FEELING IS THAT FIRE IS WASTEFUL OF ALL RESOURCES. AS DEMANDS FOR THESE RESOURCES INCREASE, INTENSIVE USE OF OTHER OPTIONS FOR FOREST MANIPULATION WHICH ARE LESS WASTEFUL SHOULD BE USED. ALTHOUGH USE OF FIRE MAY BE THE MOST ECONOMICAL ON A SHORT TERM BASIS' LONG TERM ANALYSIS SHOULD SHOW THAT IT IS DETRIMENTAL IN THE LONG RUN. ECONOMIC EFFECTS,FIRE EXCLUSION,FIRE EFFECTS,HUMAN ECOLOGY,VALUE JUDGEMENT

624. 10 541 I AM DISCOURAGED FROM USING PRESCRIBED BURNING AS A MANAGEMENT TOOL IN MOUNTAINOUS LANDS DUE TO SOIL AND HYDROLOGIC CONSIDERATIONS. GENERALLY MOUNTAIN SOILS DO NOT HAVE THE CAPACITY TO WITHSTAND CONTROLLED BURNS. VERY SELDOM DOES ONE ACHIEVE THE BURN AS PRESCRIBED DUE TO FUEL DISTRIBUTION AND CHANGING WEATHER CONDITIONS. THE RESULT IS USUALLY EITHER AN INADEQUATE BURN OR A DESTRUCTIVE BURN WHICH DESTROYS THE PRODUCTIVITY OF THE SITE. WHEN MANAGING MOUNTAIN FOREST LAND IN A MULTI-PURPOSE SITUATION, ALTERNATE OPTIONS OF STAND MANIPULATION SHOULD BE USED RATHER THAN FIRE EXCEPT FOR PILING AND BURNING SLASH ON SLOPES EXCEEDING 30%. MOUNTAIN,FIRE EFFECTS,SOIL,PRESCRIBED FIRE,HYDROLOGY,MICROCLIMATE,PRODUCTIVITY

625. 10 541 THE QUESTION OF FIRE IN UNMANAGED LANDS SUCH AS WILDERNESS IS ONE NEEDING FURTHER STUDY. THIS PHILOSOPHY CREATES PROBLEMS IN PROTECTING ADJACENT MANAGED LANDS AS WELL AS PROTECTING THE GENERAL CHARACTER OF THE LAND IN QUESTION. A GOOD EXAMPLE OF ADVERSE EFFECTS OF UN-MANAGED LAND ON ADJACENT LAND IS THE CURRENT INSECT EPIDEMIC IN YELLOWSTONE NATIONAL PARK AS IT THREATENS FOUR ADJACENT NATIONAL FORESTS. WHAT WILL BE THE CHARACTER OF THAT GENERAL AREA TEN YEARS FROM NOW? POSSIBLY A "SEA OF SNAGS". VALUE JUDGEMENT,FIRE EXCLUSION,INSECT,GENERAL FIRE MANAGEMENT

626. 10 541 THERE ARE CERTAIN ECOSYSTEMS WHICH ARE DEPENDENT ON FIRE FOR THEIR EXISTENCE. THE QUESTION WHICH MUST BE ANSWERED IS WHETHER IT IS MORE IMPORTANT TO MAINTAIN THESE ECOSYSTEMS OR SHOULD FIRE BE ELIMINATED ALLOWING TRANSITION TO ANOTHER ECOSYSTEM? FIRE EFFECTS,ECOSYSTEM,FIRE EXCLUSION,VALUE JUDGEMENT

627. 10 689 VIRTUALLY ALL GAME MANAGERS WHO DEAL WITH LARGE, UNDULATING POPULATIONS THAT PREDOMINATELY UTILIZE BOTH BROWSE AND GRASS SPECIES FOR FOOD SUPPLIES HAVE REALIZED THAT CLIMAX CONIFEROUS FOREST STANDS CONTRIBUTE VERY LITTLE TO THE ANNUAL PRODUCTION OF FOOD SUPPLY. THEREFORE, ANY MEANS THROUGH WHICH THIS SOLID OVERSTORY OF FOREST CANOPY CAN BE REMOVED TENDS TO INCREASE THE AVAILABLE FOOD SUPPLY FOR SUBSISTENCE OF THESE ANIMALS AND THEREBY DISPERSES GIVEN POPULATIONS OVER A LARGER AREA OF GROUND. AS A RESULT, WE ARE CONSTANTLY SEARCHING FOR METHODS THROUGH WHICH STANDS OF THIS TYPE COULD BE REMOVED IN ORDER TO INCREASE AVAILABLE FOOD SUPPLIES IN AN EFFORT TO INCREASE THE OVERALL NUMBERS IN GIVEN POPULATIONS. UP UNTIL THIS POINT IN TIME, TIMBERING OPERATIONS HAVE SUPPLIED THE BASIC PROCEDURE FOR ATTAINING THESE GOALS. HOWEVER, SUCH OPERATIONS REQUIRE THE CONSTRUCTION OF NUMEROUS ROAD SYSTEMS WHICH ULTIMATELY INCREASES PUBLIC USE ON AN ANNUAL BASIS, WHICH IN TURN TENDS TO FORCE ANIMALS AWAY FROM THEM. BURNING, ON THE OTHER HAND, IS BY FAR PREFERABLE BECAUSE IT REQUIRES LESS OF A COMPLICATED ROAD SYSTEM WHICH ALLOWS PUBLIC ACCESS INTO HEAVILY USED BIG GAME AREAS. HOWEVER, THE CONTROL OF THESE BURNS IN CONJUNCTION WITH THE APPROPRIATE SIZE OF THE AREA TO BE BURNED IN RELATIONSHIP TO THE SIZE OF THE AREAS TO REMAIN FOR COVER AND PRODUCTION PURPOSES IS STILL QUESTIONABLE IN THE MINDS OF MOST GAME MANAGERS. IN ADDITION TO THIS FACT, IT IS WELL KNOWN THAT FAST BURNING CANOPY TYPE FIRES WHICH TEND TO REMOVE OVERSTORY WITHOUT BEING MATERIALLY DETRIMENTAL TO UNDERSTORY SPECIES SUCH AS BROWSE, GRASS AND FORBS IS BY FAR MORE BENEFICIAL AND PRODUCES FASTER RESULTS FOR GAME FOOD THAN DOES A SLOW BURNING FIRE WHICH TENDS TO DENUDE THE AREA COMPLETELY. THEREFORE, THE FOLLOWING QUESTIONS ARISE FROM THE STANDPOINT OF GOOD GAME MANAGEMENT: 1) WHAT PROPORTION OF A SLIGHT STAND OF CONIFEROUS FOREST SHOULD BE REMOVED? 2) SHOULD THE REMOVAL SECTIONS BE DONE ON A BLOCK BASIS OR A RANDOM PATTERN WITH IRREGULAR EDGE EFFECTS? 3) WHAT WIND VELOCITY IS NECESSARY TO PRODUCE A CANOPY BURN WITH THE LEAST POSSIBLE EFFECT ON THE

EXISTING UNDERSTORY SPECIES? WILDLIFE,GAME ANIMAL,SHRUB UNDERSTORY,HERBAGE UNDERSTORY,MANIPULATION COMPARISON,AREA SIZE,CROWN BURN,FIRE EFFECTS,HUMAN ECOLOGY

628. 10 691 AS A FIRE MANAGER, I AM INTERESTED IN THE EXTENT OF DAMAGE DONE TO A STREAM DUE TO FIRE EFFECTS, I.E. SILTATION, EROSION, ETC., SPECIFICALLY IN REGARD TO LOSS OF FISH AND FISH FOOD PRODUCTION. IT WOULD BE OF INTEREST TO KNOW HOW RAPIDLY A STREAM CAN REPAIR ANY DAMAGE DONE AFTER A FIRE. FISH,FIRE EFFECTS,STREAM,TIMING,SOIL EROSION,STABILITY

629. 10 732 DOES FIRE IN OAK BRUSH (GAMBEL OAK) INCREASE SPROUTING MORE THAN MECHANICAL METHODS OF ELIMINATION? DECIDUOUS FOREST,REPRODUCTION,FIRE EFFECTS,MANIPULATION COMPARISON,HUMAN DISTURBANCE

630. 10 732 HAVE WE CREATED A "LARGE FIRE SITUATION" IN OUR MATURE TIMBER STANDS BY EXCLUDING GROUND FIRES? SHOULD WE BE BROADCAST BURNING TO ELIMINATE SOME GROUND COVER? IS THIS PRACTICAL ANYMORE WITH THE INCREASE IN PRIVATE DEVELOPMENTS (HOME SITES) IN AND ADJACENT TO THE FOREST? HUMAN ECOLOGY,FIRE EXCLUSION,FLAMMABILITY,PRESCRIBED FIRE,FUEL REDUCTION

631. 10 733 HOW CAN WE DETERMINE INTERIOR STEM DAMAGE CAUSED BY HIGH VELOCITY INTENSE FIRE IN LODGEPOLE PINE? OFTEN, THE OUTSIDE STEMS SHOW LITTLE EFFECT, HOWEVER, INTERIOR CELL STRUCTURE IS DAMAGED RESULTING IN BADLY SPLIT STEMS AFTER SEVERAL WEEKS. WE NEED SOME WAY TO MEASURE THIS DAMAGE. STEM,ORGAN,FIRE EFFECTS,EXPERIMENT ORIENTED QUESTION,CONIFEROUS FOREST,FIRE INTENSITY,FIRE BEHAVIOR

632. 10 733 WHAT EFFECT DOES FIRE ASH HAVE ON THE FISH SPAWNING SITES? FISH,ASH,REPRODUCTION,STREAM

633. 10 733 WHEN IS THE PRIME TIME TO REHABILITATE BURNED OVER TIMBER SITES IN COLORADO AS TO THE AVAILIBILITY OF MINERALS, MOISTURE FOR THE SEEDLINGS, A) SOON AFTER FIRE, OR B) IN THE SPRING AFTER WINTER MOISTURE? SOIL,NUTRIENTS,PLANTING,TIMING

634. 10 751 FIRST, LET ME SAY THAT I AGREE WITH THE STATEMENT IN YOUR LETTER REGARDING FORESTRY RESEARCH BEING TOO FAR REMOVED FROM THE NEEDS OF THE MAN ON THE GROUND. I AM NOT AT ALL CERTAIN THAT YOUR PROJECT MIGHT NOT PRODUCE SIMILAR RESULTS. ADDITIONAL KNOWLEDGE OF THE ECOLOGICAL EFFECTS OF FIRE IS ALWAYS OF GENERAL INTEREST. HOWEVER, THE APPLICATION OF SUCH KNOWLEDGE IS AN ENTIRELY DIFFERENT MATTER INSOFAR AS THE MAJORITY OF LAND MANAGERS IS CONCERNED. IN ANY EVENT THE EXCLUSION OF FIRE, FIRE USE, OR THE DEGREE OF LET-BURN MANAGEMENT NOW IN VOGUE IS NOT NECESSARILY BASED ON THE EFFECTS OF FIRE BURN BUT OTHER PRESSURES CONTINUALLY FACED BY THE LAND MANAGER. FUNDING, PERSONNEL, PUBLIC ATTITUDES, GOVERNMENTAL POLICIES AND REGULATIONS, ETC. WITHOUT COMPLETE, RIGID CONTROL OF A PARTICULAR LAND BASE THE MANAGER HAS A VERY LIMITED CAPABILITY OF UTILIZING

RESEARCH RESULTS REGARDLESS OF THEIR VALIDITY AND DESIRABLIITY. VALUE JUDGEMENT,HUMAN ECOLOGY,FIRE EXCLUSION,FIRE EFFECTS

635. 11 059 DOES FIRE PROMOTE THE ESTABLISHMENT OF HYDROPHOBIC SOILS? IF SO, IN WHAT MANNER AND TO WHAT DEGREE? EXPERIMENT ORIENTED QUESTION,SOIL-WATER RELATIONS

636. 11 059 WHAT EFFECTS DO DIFFERENT SILVICULTURAL PRACTICES (TIMBER HARVESTING TECHNIQUES) HAVE ON FUEL LOADINGS? MANIPULATION COMPARISON,FUEL/BIOMASS ACCUMULATION

637. 11 066 WHAT MIGHT BE THE EFFECT OF CHANGING THE DENSITY OF DEAD, STANDING SNAGS AS SEEN IN THE FIRE FREQUENCY FOR THE AREA, AND POPULATION DENSITIES OF INSECT PESTS, BEE POLLINATORS, INSECTIVOROUS AND CARNIVOROUS BIRDS? SNAG,INSECT,BIRD

638. 11 196 HOW DOES FIRE OF DIFFERENT INTENSITIES, ON A GIVEN SITE, AFFECT THE PROBABILITY OF RECURRENCE OF FIRES IN LATER YEARS? FIRE INTENSITY,FIRE FREQUENCY

639. 11 196 HOW DOES THE HYDROLOGIC REGIME OF A WATERSHED CHANGE AFTER FIRES OF DIFFERENT INTENSITIES SUCH AS GROUND FIRE OR CROWN FIRE? SPECIFICALLY, HOW DOES FIRE AFFECT RUNOFF, OVERLAND FLOW, INFILTRATION RATES, AND INTERFLOW? ONCE THESE EFFECTS OCCUR, HOW LONG DO THEY REMAIN ON A BURNED WATERSHED? WATERSHED,HYDROLOGY,FIRE INTENSITY,TIMING

640. 11 196 WHAT CHANGES ARE MADE IN DRY WEIGHT OF STANDING LIVE, STANDING DEAD, AND DOWN FUELS FOLLOWING FIRES OF DIFFERENT INTENSITIES? FIRE BEHAVIOR,FUEL REDUCTION

641. 11 196 WHAT DOES THE EFFECT OF FIRE MANAGEMENT ATTITUDE (SUCH AS LETTING FIRES OF LOW INTENSITY BURN OUT UNDER FAVORABLE CONDITIONS VERSUS PUTTING OUT ALL FIRES) HAVE ON NATIONAL FOREST BUDGETS WITH REGARD TO MAINTAINING OR REDUCING INITIAL ATTACK FORCES, EQUIPMENT, AND PRESUPPRESSION COSTS? HOW DO VARIOUS CUTTING PRACTICES AFFECT THESE COSTS? GENERAL FIRE MANAGEMENT,ECONOMIC EFFECTS

642. 11 196 WHAT EFFECT DO VARIOUS METHODS OF HARVEST SUCH AS CLEARCUT, THINNING, STRIPCUTTING, ETC., HAVE ON FIRE IGNITION, RATE OF SPREAD, AND CONTROLABILITY? WHAT EFFECTS DO CUTTING PRACTICES HAVE ON DRY WEIGHT OF LIVE, DEAD, AND DOWN FUELS? MANIPULATION COMPARISON,FIRE BEHAVIOR, FUEL/BIOMASS ACCUMULATION

643. 11 196 WHAT IS THE DETERIORATION RATE OF FUELS FOLLOWING FIRES OF VARIOUS INTENSITIES, AND HOW DOES THIS COMPARE WITH LOGGING SLASH FOLLOWING PILING AND BURNING, OR COMPARED WITH THE DETERIORATION RATE OF SLASH WHICH HAS BEEN CHOPPED AND SCATTERED? DECOMPOSITION,FIRE INTENSITY,MANIPULATION COMPARISON

644. 11 200 ON SITES WHERE ARIZONA FESCUE BECOMES ESTABLISHED, PONDEROSA PINE IS EXCLUDED. IS THIS A PERMANENT

CONDITION? WILL THE FESCUE DISAPPEAR AFTER A LENGTH OF TIME, OR IS IT NECESSARY FOR FIRE TO PREPARE THE SITE BEFORE THE PINE CAN RE-ESTABLISH ITSELF? IN THE PINUS PONDEROSA-FESTUCA ARIZONICA ASSOCIATION IN THE SOUTHWEST, WHICH IS THE CLIMAX SPECIES? COMPETITION,VEGETATION,SUCCESSION

645. 11 201 UNDER WHAT CONDITIONS DO ASPEN STANDS BURN HOT ENOUGH THAT THE STEMS ARE KILLED? THIS WILL VARY, OF COURSE, WITH THE NATURE OF THE SUBORDINATED VEGETATION. DECIDUOUS FOREST,FIRE INTENSITY,HEAT EFFECTS,STEM,MORTALITY

646. 11 201 WHAT IS THE AREAL DISTRIBUTION OF FIRE-INDUCED SOIL-WATER REPELLENCY FOLLOWING LIGHT SURFACE FIRES? SEVERE FIRES? IN DIFFERENT SOILS, HABITAT TYPES, AND STAND TYPES? WHAT ARE THE FACTORS THAT DISRUPT AND BREAK DOWN WATER REPELLENT LAYERS? HOW LONG ARE SUCH LAYERS EFFECTIVE? SOIL-WATER RELATIONS,FIRE INTENSITY

647. 11 288 WHAT IS THE FREQUENCY OF LIGHTNING STRIKES AMONG DEAD TREES OR SNAGS, AND WHAT ARE THE CONSEQUENCES OF SUCH STRIKES? ARE RIDGE TOP TREES MORE STRIKE PRONE THAN TREES ON SLOPES? DOES THE ELIMINATION OF DEAD TREES DURING TIMBER HARVESTS SIGNIFICANTLY REDUCE THE NUMBER OF LIGHTNING FIRES? SNAG,FIRE FREQUENCY,LIGHTNING-CAUSED FIRE

648. 11 288 WOULD RODENT CONTROL AFTER SOME FIRES INCREASE CHANCES OF REFORESTATION BY SPROUTING OR BY THE FEW VIABLE SEEDS AVAILABLE ON THE GROUND AND FROM TREES NOT KILLED BY THE FIRE? SMALL MAMMAL,REPRODUCTION,SEED,HERBIVORY

649. 11 289 WHAT IS THE EFFECT OF CHANGING THE FIRE FREQUENCY AND INTENSITY AS SEEN IN UNDERSTORY VEGETAL PRODUCTIVITY IN PONDEROSA PINE OF NORTHERN NEW MEXICO? FIRE FREQUENCY,FIRE INTENSITY,SHRUB UNDERSTORY,PRODUCTIVITY,SUCCESSION

650. 11 307 IS THERE A RELATIONSHIP BETWEEN FIRE EXCLUSION AND THE POPULATION DYNAMICS OF THE SPRUCE BARK BEETLE? INSECT,FIRE EXCLUSION

651. 11 307 WHAT ARE THE EFFECTS OF FUEL CONSUMPTION BY FIRE ON THE POPULATIONS OF THE SOIL MICROBIOTA? ARE THERE SIGNIFICANT CHANGES IN THEIR PRODUCTIVITY? TAXA OF INTEREST TO ME ARE THE ACTINOMYCETES, ASCOMYCETES, NITROBACTER, NITROSOMONAS, VIBRIO, PSEUDOMONAS AND THE ORIBATID MITES. FUEL REDUCTION,MICROORGANISM,SOIL

652. 11 307 WHAT ARE THE EFFECTS OF PRESCRIBED BURNING ON THE NET PRODUCTIVITY OF COMMON WESTERN TREES? HOW WELL ARE THESE CHANGES REFLECTED BY TREE-RING INCREMENTS? PRESCRIBED FIRE, PRODUCTIVITY,VEGETATION,STEM

653. 11 307 WHAT ARE THE EFFECTS OF PRESCRIBED FIRE ON THE CYCLING RATES FOR POTASSIUM, NITROGEN AND PHOSPHOROUS? HOW DO THESE RATES CHANGE WITH TIME? NUTRIENTS,PRESCRIBED FIRE

654. 11 307 WHAT ARE THE EFFECTS OF VARIOUS ENERGY-RELEASE RATES ON ARCEUTHOBIUM POPULATIONS IN PONDEROSA PINE? EPIPHYTE,FIRE INTENSITY

655. 11 307 WHAT IS THE RELATIONSHIP BETWEEN ENERGY-RELEASE RATES AND DIAMETERS OF KILLED TREES, FOR COMMON SPECIES OF WESTERN TREES? SIZE CLASS,MORTALITY,FIRE INTENSITY

656. 11 544 CAN LIGHTNING BE CONTROLLED BY SETTING UP SOME TYPE OF LIGHTNING ARRESTER OR OTHER METHOD, AND IF SO, COULD IT BE OPERATED ONLY DURING TIMES THAT FIRES WILL CAUSE DAMAGE? LIGHTNING EFFECTS,LIGHTNING-CAUSED FIRE

657. 11 544 IF ALL SNAGS ARE REMOVED FROM AN AREA IN THE SOUTHWESTERN U.S., WHAT WILL BE THE EFFECT ON THE BIRD-INSECT RELATIONSHIP? BIRD,SNAG,INSECT,HUMAN DISTURBANCE

658. 11 544 WHAT EFFECT DOES A FIRE HAVE ON THE AREA OUTSIDE THE FIRE AND HOW FAR DOES THE EFFECT REACH? FIRE EFFECTS,ECOTONE,AREA SIZE

659. 11 545 DOES INITIAL AND REPEATED BROADCAST BURNING REDUCE THE FOOD SUPPLY OF THE ABERT SQUIRREL? SMALL MAMMAL,FIRE EFFECTS,POPULATION,FIRE FREQUENCY,PRESCRIBED FIRE

660. 11 545 DOES PERIODIC BROADCAST BURNING AID NATURAL SEED GERMINATION AND SEEDLING ESTABLISHMENT? WHAT IS THE TIME FACTOR IN RELATION TO SEED CAST? TIMING,PRESCRIBED FIRE,SEED,REPRODUCTION,DISPERSION,GROUND FIRE

661. 11 545 UNDER WHAT CONDITIONS CAN FIRE BE USED AS A MANAGEMENT TOOL TO REDUCE COMBUSTIBLE FUELS, WITHOUT DESTROYING THE TREE RESOURCE, IN A FOREST TYPE (PONDEROSA PINE WITH A WOODY UNDERSTORY) WHERE FUELS HAVE BUILT UP OVER THE PAST 50 YEARS AND THERE IS A DIFFERENTIAL IN TREE SIZE, AGE, AND DISTRIBUTION? PRESCRIBED FIRE,FUEL REDUCTION,SHRUB UNDERSTORY,FUEL/BIOMASS ACCUMULATION,CONIFEROUS FOREST

662. 11 545 WHAT ARE THE CHANGES IN THE MICROCLIMATE FOLLOWING A GROUND BROADCAST BURN? MICROCLIMATE,GROUND FIRE,FIRE EFFECTS

663. 11 545 WHAT EFFECT DOES PERIODIC BURNING HAVE IN THE NUTRIENT RECYCLING PROCESS? WHAT IS THE PERCENT RECOVERY OF NUTRIENTS BY PLANT GROWTH AFTER BURNING? IS THE TREE GROWTH RATE INCREASED DUE TO A GREATER ABUNDANCE OF NUTRIENTS AFTER BURNING? FIRE EFFECTS,NUTRIENTS,FIRE FREQUENCY,PRODUCTIVITY,POPULATION GROWTH

664. 11 545 WHAT IS THE FREQUENCY OF BURNING NEEDED TO CONTROL COMPETITIVE PLANT SPECIES SUCH AS TURBINELLA OAK, MANZANITA, AND ALLIGATOR JUNIPER? FIRE FREQUENCY,PRESCRIBED FIRE,SHRUB UNDERSTORY,CONIFEROUS FOREST,COMPETITION

665. 11 545 WHAT IS THE OPTIMUM AREA TO BURN IN RELATION TO MULE DEER HABITAT? WHAT ARE THE EFFECTS OF BURNING ON MULE DEER POPULATIONS IN RELATION TO HABITAT CONDITIONS AFTER INITIAL AND REPEATED BURNING? AREA SIZE,GAME ANIMAL,FIRE EFFECTS,FIRE FREQUENCY,PRESCRIBED FIRE

666. 11 545 WILL A PONDEROSA PINE SEEDLING MORE LIKELY SUCCUMB TO MOISTURE STRESS IN A BURNED AREA VERSUS AN UNBURNED AREA? MORTALITY,SOIL-WATER RELATIONS,CONIFEROUS FOREST

667. 11 546 FUEL BREAKS ARE BEING UTILIZED CONSIDERABLY IN THE SOUTHWEST IN PREATTACK PLANNING. WE AS YET DO NOT HAVE GOOD INFORMATION ON HOW MUCH VALUE FUELBREAKS WOULD HAVE, WHAT WIDTHS ARE BEST ETC., IN SOUTHWESTERN PONDEROSA PINE. FIRE EXCLUSION,GENERAL FIRE MANAGEMENT,HUMAN DISTURBANCE

668. 11 546 HOW MUCH ASH OR CARBON CONTACT CAN A TROUT FISHERY WITHSTAND WITHOUT SUBSTANTIAL LOSS OF FISH? FISH,STREAM,FIRE EFFECTS,CHARCOAL

669. 11 546 LOSS OF TREES THROUGH SCORCHING AND EXCESSIVE HEAT AT THE BOLE IS A PROBLEM IN ALL TYPES OF PRESCRIBED BURNING IN THE SOUTHWEST. HOW CAN WE MINIMIZE THIS? WHAT MAXIMUM BOLE TEMPERATURES CAN BE TOLERATED? HOW MUCH LIVE CROWN CAN WE LOSE AND STILL SAVE THE TREE? CROWN,CROWN BURN,MORTALITY,CONIFEROUS FOREST,STEM,ORGAN,PRESCRIBED FIRE,HEAT EFFECTS,FIRE INTENSITY

670. 11 546 WHAT INTENSITY OF FIRE IS REQUIRED FOR SERIOUS DAMAGE TO SOIL MICROORGANISMS AND BACTERIA? FIRE INTENSITY,SOIL,MICROORGANISM

671. 11 547 BLACKENED GROUND ABSORBS SOLAR HEAT FASTER AND DEEPER THAN NATURALLY COLORED SURFACES. WARMTH CAUSES EARLIER SPRING GROWTH. WHAT IS THE AFFECT OF FROST, SNOW, SPRING WINDS, ETC. ON SUCCULENT GROWTH FOR AN EARLIER START ON BURNED LAND AS COMPARED TO GRASS THAT GREENS UP NATURALLY A MONTH LATER ON UNBURNED SOIL? ARE THERE ANY COMPARISONS OF THIS FOR A LONG ENOUGH TIME TO HAVE AVERAGE TYPE WEATHER OR SPRING DATA? FIRE EFFECTS,SNOW,MICROCLIMATE,CHARCOAL,ASH,PRODUCTIVITY,REPRODUCTION

672. 11 547 COULD THERE BE A LATENT SIDE EFFECT TO PRESCRIBED BURNING IN SPRING OR FALL INSTEAD OF DURING THE TIME MOTHER NATURE DOES HER IGNITING? I MEAN IS THERE A POSSIBLE ECOLOGICAL FACTOR WE AREN'T CONSIDERING WHEN WE BURN IN THE FALL TO REDUCE FIRE HAZARD, BUT DURING A SEASON WHEN WE ARE CONFIDENT WE CAN CONTROL OUR FIRE? FIRE EFFECTS,PRESCRIBED FIRE,LIGHTNING-CAUSED FIRE,PRESCRIBED FIRE,TIMING,ECOSYSTEM

673. 11 547 WITHIN ANY GIVEN AREA WHERE FIRE IS EXCLUDED, IS THERE A MAXIMUM DEPTH TO WHICH NATURAL DEBRIS (FALLING NEEDLES, LEAVES, TREES THEMSELVES, ETC.) BUILDS? OR DOES THE HUMUS SIMPLY KEEP GETTING DEEPER AND DEEPER? IN OTHER WORDS IS THERE A CERTAIN POINT TO WHICH SOIL AND HUMUS REACH A STABLE POINT? FUEL/BIOMASS

ACCUMULATION,FIRE EXCLUSION,SOIL,DUFF

674. 11 548 HAVE ANY STUDIES BEEN COMPLETED ON THE EFFECTS OF CONTROLLED BURNING ON GAME POPULATIONS, PARTICULARLY NESTING BIRDS AND SMALL MAMMALS? SMALL MAMMAL,BIRD,PRESCRIBED FIRE,FIRE EFFECTS

675. 11 552 ARIZONA CYPRESS (CUPRESSUS ARIZONICA) GROWS IN PURE STANDS IN ISOLATED POCKETS IN VARIOUS PORTIONS OF THE SYCAMORE CANYON WILDERNESS AREA. WHAT OCCURRENCE OR ABSENCE OF FIRE CONTRIBUTES TO THIS UNIQUE GROWTH PATTERN? FIRE EFFECTS,FIRE EXCLUSION,POPULATION,CONIFEROUS FOREST

676. 11 552 DOG-HAIR THICKETS OF SECOND GROWTH PONDEROSA PINE ARE A COMMON OCCURRENCE BELOW THE MOGOLLON RIM IN ARIZONA. DUE TO THE LIMITED TIMBER RESOURCE, THINNING AND WEEDING CAN ONLY BE APPLIED IN A VERY LIMITED FASHION. CAN, AND WILL, FIRE SOMEDAY BE SUBSTITUTED, UNDER PRESCRIPTION, AS A CULTURAL PRACTICE? PRESCRIBED FIRE,COMPETITION,DENSITY,CONIFEROUS FOREST

677. 11 552 THE PRACTICE OF IMMEDIATELY SEEDING A MAJOR FIRE TO GRASSES MAY INHIBIT FUTURE EFFORTS AT NATURAL AND ARTIFICIAL REGENERATION OF PONDEROSA PINE. CAN FIRE BE USED AS A TOOL FOR SITE PREPARATION TO REDUCE COMPETITION FROM GRASS AND GRASS-LIKE VEGETATION UNDER THE HARSH CONDITIONS OCCURRING BELOW THE MOGOLLON RIM IN ARIZONA? GRASSLAND,FIRE EFFECTS,REPRODUCTION,COMPETITION,CONIFEROUS FOREST,PRESCRIBED FIRE

678. 11 553 DOES CHARRED FUEL AFFORD RESISTANCE TO IGNITION? IN OTHER WORDS WILL A COOL FIRE THROUGH, SAY THINNING SLASH, REDUCE THE HAZARD? FIRE EFFECTS,CHARCOAL,FLAMMABILITY,FIRE INTENSITY

679. 11 819 WHAT IS THE PROBABILITY OF A FIRE STARTING WHEN LIGHTNING STRIKES A DEAD STANDING TREE AND THE PROBABILITY OF A FIRE STARTING WHEN LIGHTNING STRIKES A GREEN LIVE TREE? LIGHTNING EFFECTS,LIGHTNING-CAUSED FIRE,FIRE FREQUENCY,SNAG,CONIFEROUS FOREST

680. 11 819 WHAT IS THE PROBABILITY OF LIGHTNING STRIKING A DEAD STANDING TREE AS OPPOSED TO A LIVE TREE? LIGHTNING EFFECTS,SNAG,CONIFEROUS FOREST

681. 11 819 WHAT ORGANISMS INHABIT DEAD TREES AND ARE THE DEAD TREES AN ESSENTIAL PORTION OF THEIR LIFE CYCLE? IF SO, WHAT ARE THE BENEFICAL AND DETRIMENTAL EFFECTS OF THESE ORGANISMS TO MANKIND? IS IT MORE IMPORTANT TO LEAVE THESE DEAD TREES STANDING FOR ORGANISMS, ANIMALS AND BIRDS OR TO DROP AND REMOVE THEM AND REDUCE A LIGHTNING/FIRE HAZARD? SNAG,FIRE FREQUENCY,ANIMALS,VALUE JUDGEMENT,ECOSYSTEM

682. 12 564 ARE THERE LONG-TERM ENVIRONMENTAL EFFECTS OF LARGE FIRES, SUCH THAT THE ECOSYSTEM IS IRREPARABLY DAMAGED? OR ARE THE ADVERSE EFFECTS SHORT-TERM, AND MAY THEY BE

NEGATED IN THE LONG RUN THROUGH PRODUCTION OF INCREASED BIOMASS? FIRE INTENSITY,AREA SIZE,SUCCESSION,FUEL/BIOMASS ACCUMULATION

683. 12 564 DO AGGRESSIVE FIRE CONTROL PROCEDURES ENHANCE THE POSSIBILITY OF DISASTROUS FIRES DUE TO TREMENDOUS FUEL BUILD-UPS. FIRE EXCLUSION,FIRE BEHAVIOR,FUEL/BIOMASS ACCUMULATION,PRODUCTIVITY,SUCCESSION

684. 12 564 WHAT ARE THE LONG RANGE EFFECTS OF SMALL OPEN PARKS BEING ALLOWED TO RESEED WITH SPRUCE, FIR AND PINE, ON WILDLIFE SPECIES (ELK, DEER, BEAR, ETC.)? FIRE EXCLUSION,ANIMALS,SUCCESSION,VEGETATION,AREA SIZE

685. 12 567 WHAT ECOLOGIC CHANGES HAVE RESULTED IN THE PONDEROSA PINE TYPE IN NEW MEXICO THROUGH THE EXCLUSION OF FIRE? COMMENT- IN MANY AREAS OF THE SOUTHWEST, WE FIND LARGE AREAS OF "DOG-HAIR" THICKETS WHICH HAVE GROWN UP IN THE LAST 20-60 YEARS. PRESENTLY, THEY ARE BIOLOGICAL DESERTS AND CERTAINLY FIRES, IF ALLOWED TO BURN IN THE PAST, WOULD HAVE CHANGED THIS SITUATION. MANAGEMENT ACTIVITIES SUCH AS THINNING, LOGGING, ETC., CAN REPLACE FIRE TO SOME EXTENT IN THE REMOVAL OF TREES. HOWEVER, WE ARE STILL LEFT WITH A BUILD-UP OF DUFF WHICH APPEARS TO BE A BARRIER TO THE PENETRATION OF WATER INTO THE SOIL AND TO THE ESTABLISHMENT OF OTHER PLANTS (GRASS, FORBS, BROWSE, ETC.). FIRE EXCLUSION,CONIFEROUS FOREST,HERBAGE UNDERSTORY,SOIL-WATER RELATIONS,LITTER,DUFF

686. 12 568 DOES PROPERLY APPLIED PRESCRIBED BROADCAST BURNING HAVE A SIGNIFICANT EFFECT ON THE GROWTH RATE OF LIVE TREES AS OPPOSED TO THE GROWTH RATE WHERE SLASH DISPOSAL IS ACCOMPLISHED BY ALTERNATE METHODS? I WOULD LIKE TO SEE MORE RESEARCH INTO THE RELATIONSHIPS BETWEEN CAMBIUM TEMPERATURE, DURATION OF HEAT, TREE SPECIES, SIZE, BARK THICKNESS, ETC. AS THESE RELATE TO KILLING OF TREES IN SURFACE FIRES. PRESCRIBED FIRE,POPULATION GROWTH,MANIPULATION COMPARISON,ORGAN,HEAT EFFECTS,STEM,MORTALITY,CONIFEROUS FOREST,FIRE EFFECTS

687. 12 569 HOW WOULD BE THE BEST WAY TO PLACE A SOUTHWESTERN NEW MEXICO WILDERNESS AREA BACK INTO ITS NATURAL STATE AND HOW LONG WOULD BE REQUIRED TO DO SO, STRICTLY FROM A NATURAL FIRE STANDPOINT? ARE HOT, JUNE FIRES NECESSARY IN A WILDERNESS AREA TO PERPETUATE NATURAL CONDITIONS OR COULD COOLER, LATE SEASON FIRES DO THE REQUIRED JOB? ARE HOT, JUNE FIRES TRULY DISASTEROUS IN A WILDERNESS AREA OR DO THEY BRING ABOUT CHANGES AND/OR ALTERATIONS WHICH ARE DEEMED DESIRABLE IN WILDERNESS AREAS? VALUE JUDGEMENT,FIRE EXCLUSION,FIRE EFFECTS,TIMING,FIRE INTENSITY

688. 12 570 HOW MANY TONS/ACRE OF FUEL ARE REQUIRED TO SUPPORT A CROWN FIRE IN PONDEROSA PINE AND IN MIXED CONIFER FOREST IN THE SOUTHWEST? FUEL/BIOMASS ACCUMULATION,CROWN BURN,CONIFEROUS FOREST,FIRE BEHAVIOR

689. 12 570 WILL LOGGING, AS IS NOW PRACTICED IN THE SOUTHWEST, DO THE SAME JOB AS FIRE ONCE DID IN KEEPING

PONDEROSA PINE GROWING IN RELATIVELY PURE STANDS, OR WILL FIR SPECIES AND DOUGLAS-FIR COME IN AND FORCE OUT THE PINE OR ESTABLISH A MIXED STAND? SUCCESSION,FIRE EXCLUSION,HUMAN DISTURBANCE,MANIPULATION COMPARISON,ECOSYSTEM,COMPETITION,SPECIES DIVERSITY

690. 12 572 WHAT IS EFFECT OF TIMING OF UNDERSTORY PRESCRIBED FIRE (GROWING SEASON VS. OTHER SEASON) ON POLE-SIZED SOUTHWESTERN PONDEROSA PINE, AS OBSERVED IN: RESISTANCE TO FIRE EFFECTS, RESISTANCE TO INSECT ATTACK, GROWTH RATE? FIRE EFFECTS,CONIFEROUS FOREST,POPULATION,INSECT,STEM,POPULATION GROWTH,PRESCRIBED FIRE,GROUND FIRE

691. 12 610 BECAUSE FIRE DANGER IS LOW IN MOST SPRUCE-FIR FORESTS IN NEW MEXICO, MY QUESTION IS: IS MORE DAMAGE DONE BY BURNING SPRUCE-FIR FOREST TYPES FOR SLASH REDUCTION FOLLOWING LOGGING THAN LEAVING THESE FOREST TYPES AS UNDISTURBED AS POSSIBLE? THE BEST REPRODUCTION I KNOW OF IN THE SOUTHERN ROCKY MOUNTAINS IS ON UNDISTURBED SLASH AREAS. SPRUCE-FIR AREAS THAT HAVE BEEN BURNT IN THIS AREA HAVE LITTLE OR NO REPRODUCTION ON THEM AND REMAIN UNPRODUCTIVE. THE SPRUCE-FIR SITE HAS BEEN DESTROYED BY BURNING. THE CURE FOR SLASH HAS BEEN MUCH WORSE THAN THE SLASH. FIRE EFFECTS,SOIL,PRESCRIBED FIRE,FUEL REDUCTION,REPRODUCTION,CONIFEROUS FOREST,PRODUCTIVITY

692. 12 703 CAN CONTROLLED BURNING BE USED TO CONTROL VARIOUS INSECT INFESTATIONS IN FOREST ECOSYSTEMS? INSECT,FIRE EFFECTS,PRESCRIBED FIRE

693. 12 703 IN AREAS THAT HAVE A LONG HISTORY OF PROTECTION FROM BURNING AND WHERE A LARGE AMOUNT OF BURNABLE MATERIAL HAS BUILT UP ON THE FOREST FLOOR, CAN A CONTROLLED BURN BE CONDUCTED WITHOUT EXCESSIVE HEAT HARMING THE TOP SOIL LAYER? PRESCRIBED FIRE,FIRE EXCLUSION,SOIL,HEAT EFFECTS,FUEL/BIOMASS ACCUMULATION

694. 12 703 IN USING CONTROLLED BURNING FOR CREATION OF BIG GAME HABITAT, WHAT SIZE BURN IS OPTIMAL FOR MAXIMUM UTILIZATION AND HOW MUCH OF A BELT SHOULD BE LEFT BETWEEN BURNS? AREA SIZE,GAME ANIMAL,PRESCRIBED FIRE,ECOTONE

695. 12 703 TO CARRY THE IDEA OF WILDERNESS AREAS TO ITS FULLEST MEANING, SHOULDN'T FOREST FIRES BE ALLOWED TO BURN IN WILDERNESS AREAS WHERE NO HARM CAN COME TO PEOPLE OR PROPERTY? VALUE JUDGEMENT,FIRE EXCLUSION,FIRE EFFECTS

696. 12 735 FIRES THAT ARE NOT DANGEROUS AND COULD BE LEFT TO BURN OUT MUST STILL BE MANNED BECAUSE OF PUBLIC OPINION. THE EXPENSE OF MANNING THESE FIRES CAN BE OUT OF PROPORTION TO THE VALUE OF THE RESOURCE. HOW DO WE EDUCATE THE PUBLIC ON FIRES AS A NATURAL OCCURRENCE? FIRE EXCLUSION,ECONOMIC EFFECTS,VALUE JUDGEMENT,PUBLIC REACTION

697. 12 736 AT WHAT POINT DOES THE SOIL BECOME DAMAGED WHEN BURNING SLASH? HOW DOES ONE DETERMINE THAT THE FIRE IS HOT ENOUGH TO GET COMPLETE COMBUSTION WITHOUT DAMAGING THE SITE? SOIL,HEAT EFFECTS,FUEL REDUCTION,FIRE EFFECTS

698. 12 736 WHAT ARE THE MAXIMUM TEMPERATURES OR FUEL CONDITIONS THAT PONDEROSA PINE CAN WITHSTAND IN THE VARIOUS SIZE CLASSES? SIZE CLASS,HEAT EFFECTS,FIRE INTENSITY,CONIFEROUS FOREST

699. 12 736 WHAT STAND OR CROWN DENSITY IS REQUIRED TO CARRY A FIRE IN STANDING PINON-JUNIPER STANDS? CROWN BURN,CROWN,FLAMMABILITY,FIRE BEHAVIOR

700. 12 755 COULD THE SOIL BE TREATED EITHER PHYSICALLY OR CHEMICALLY TO ENHANCE SEED GERMINATION AND SURVIVAL? SOIL,NUTRIENTS,SEED

701. 13 055 DOES FIRE PRODUCE NITROGEN DEFICIENT CONDITIONS IN PLANT SPECIES REVEGETATING BURNED SURFACES? IS PRIMARY PRODUCTIVITY DEPRESSED OR STIMULATED BY FIRE? HOW EXTENSIVELY IS THE RATE OF NITROGEN CYCLING ALTERED FOLLOWING FIRE? A) MORE DETAILED EXAMINATION OF EXTENT TO WHICH NITROGEN TRANSFORMATION PROCESSES ARE ALTERED. NUTRIENTS

702. 13 055 TO WHAT EXTENT DOES FIRE ALTER RATES OF DECOMPOSITION OF ORGANIC DEBRIS DEPOSITED ON AND IN THE SOIL PROFILE? A) ASSOCIATED EFFECTS ON MICROBIAL POPULATIONS, B) ASSOCIATED EFFECTS ON INVERTEBRATE ANIMAL POPULATIONS DECOMPOSITION,MICROORGANISM,ARTHROPODS

703. 13 210 WHAT ARE THE EFFECTS OF FIRE ON SOIL MOISTURE FLUXES AND THE RELATIONSHIP BETWEEN THESE MOISTURE FLUXES AND PLANT DEVELOPMENT AND GROWTH? SOIL-WATER RELATIONS,VEGETATION,PRODUCTIVITY

704. 13 210 WHAT IS THE IMPACT OF FIRE EXCLUSION IN THE TAIGA ON THE EVOLUTION OF PLANTS AND ANIMALS ADAPTED TO PERIODIC BURNING? SPECIFIC EXAMPLES: THE SEMI-SEROTINOUS CONES OF BLACK SPRUCE (PICEA MARIANA). GENETIC RESPONSE,FIRE FREQUENCY,ORGAN,FIRE EXCLUSION

705. 13 210 WHAT IS THE ROLE OF FIRE IN THE MAINTENANCE OF THE TAIGA NUTRIENT BALANCE? NUTRIENTS

706. 13 211 WHAT ARE THE EFFECTS OF VARIOUS INTENSITIES OF BURNS ON THE PERMA-FROST REGIME? WHAT EFFECT, IF ANY, DO BURNS HAVE ON THE WATER RETENTION CAPACITY IN A GIVEN WATERSHED AREA? WHAT ARE THE CUMULATIVE EFFECTS OF SOIL EROSION AFTER FIRE? SOIL-WATER RELATIONS,SOIL EROSION

707. 13 212 HAS FIRE EXCLUSION IN CONIFEROUS FORESTS INCREASED SUSCEPTIBILITY OF DOUGLAS FIR TUSSOCK MOTH BY ALLOWING INCREASE IN THE TRUE FIR UNDERSTORY COMPONENT? FIRE EXCLUSION,COMMUNITY,INSECT,SHRUB UNDERSTORY,CONIFEROUS FOREST

708. 13 212 HAS SURFACE FIRE EXCLUSION IN CONIFEROUS FORESTS REDUCED POPULATIONS OF INSECTS, THAT PARASITIZE OTHER INSECTS, BY ALTERING THE SPECIES COMPOSITION OF FLOWERING AND FRUIT BEARING GROUND COVER IMPORTANT AS A FOOD SOURCE FOR ADULT PARASITOIDS, SUCH AS THE ICHNEUMONIDS? GROUND FIRE,FIRE EXCLUSION,POPULATION,INSECT,PREDATION,SPECIES DIVERSITY,HERBAGE UNDERSTORY

709. 13 212 HAS SURFACE FIRE EXCLUSION IN CONIFEROUS FORESTS RESULTED IN AN INCREASE IN POPULATIONS OF CONE FEEDING INSECTS SUCH AS CONOPHTHORUS AND OTHERS THAT SPEND A PORTION OF THEIR LIFE CYCLE IN THE LITTER? GROUND FIRE,FIRE EXCLUSION,POPULATION,INSECT,LITTER

710. 13 215 HOW LONG DOES IT TAKE FOR ROOTING SYSTEMS TO BE REVITALIZED FOLLOWING FIRE THUS NEGATING INITIAL EROSION ACCELERATION? ROOTS,PRODUCTIVITY,SOIL EROSION

711. 13 215 WHAT EFFECT DOES FIRE HAVE ON ACCELERATED SURFACE EROSION BY DRY CREEP AND RAVEL? IN THE HUMID CONIFEROUS FOREST AREAS OF THE WESTERN CASCADES AND COAST RANGES? IN THE SEMI-ARID REGIONS EAST OF THE CASCADES? WHAT EFFECT DOES FIRE HAVE ON MASS SOIL MOVEMENT? IS IT ACCELERATED IN TERMS OF NUMBER OF LANDSLIDES OR RATE OF CREEP DEFORMATION? WHAT ARE THESE INCREASES IN TERMS OF NUMBERS PER UNIT AREA OF RATES OF MOVEMENT? WHAT IS THE PRINCIPAL IMPACT OF FIRE ON SOIL EROSION? DESTRUCTION OF SURFACE COVER? DECAY OF ANCHORING AND BINDING ROOTS FOLLOWING DESTRUCTION OF SURFACE PLANT? DESSICATION? HYDROPHOBIC LAYER FORMATION? SOIL EROSION

712. 13 217 AT WHAT FREQUENCY CAN FIRES OCCUR IN ALASKAN FORESTS? WHAT ARE THE FACTORS GOVERNING FIRE FREQUENCY? FIRE FREQUENCY,FIRE BEHAVIOR,EXPERIMENT ORIENTED QUESTION

713. 13 217 CAN ASPEN, WILLOW (SALICACEAE, IN GENERAL) REPLACE BLACK SPRUCE ON FAVORABLE SITES? WHAT CONDITIONS ARE REQUIRED (E.G. FIRE INTENSITY, SEED SOURCE, SURFACE MOISTURE CONDITIONS)? COMPETITION,SUCCESSION

714. 13 217 CERTAIN SPECIES (E.G. CORYDALIS,GERANIUM) WHICH HAVE SEEDS THAT APPEAR IMMOBILE, FREQUENTLY OCCUR ABUNDANTLY FOLLOWING FIRE: WHEREAS, THEY WERE ABSENT IN THE UNBURNED FOREST. WHAT IS THE SEED SOURCE FOR THESE SPECIES; SEED STORED IN ORGANIC LAYERS OF SOIL, OR SEED TRANSPORTED BY SMALL MAMMALS? SEED

715. 13 217 HOW LONG IS THE REGENERATION PERIOD FOR INTERIOR ALASKA BLACK SPRUCE STANDS FOLLOWING FIRE? WHAT IS THE RELATIONSHIP TO FIRE INTENSITY? RELATIONSHIP TO SURFACE MOISTURE CONDITIONS? REPRODUCTION,SUCCESSION,FIRE INTENSITY,SOIL-WATER RELATIONS

716. 13 217 WHAT ARE THE BIOLOGICAL AND ABIOTIC SIMILARITIES AND DIFFERENCES BETWEEN FIRE AND DIFFERENT TYPES OF MAN-MADE DISTURBANCES? WHAT MAN-CAUSED DISTURBANCES CREATE CONDITIONS MOST SIMILAR TO THOSE CREATED BY FIRE,

AND CAN THESE DISTURBANCES BE USED TO REPLACE FIRE IN AREAS WHERE FIRE EXCLUSION MUST BE PRACTICED (RELATING PRIMARILY TO ALASKA)? MANIPULATION COMPARISON

717. 13 217 WHAT IS THE RELATIONSHIP OF WHITE SPRUCE TO FIRE IN INTERIOR ALASKA? HAS THIS FOREST TYPE INCREASED OR DECREASED AS A RESULT OF FIRE? EXPERIMENT ORIENTED QUESTION,PRODUCTIVITY

718. 13 294 IN A BURN, THERE ARE OFTEN PATCHES OF FOREST UNBURNED. THESE UNBURNED AREAS APPEAR TO OCCUR IN A RANDOM PATTERN WITHOUT REGARD TO SLOPE, ASPECT, SOIL OR MOISTURE DIFFERENCES. IS THERE A FACTOR IN THE ECOSYSTEM OF THE UNBURNED AREA THAT RESULTS IN ITS NOT BURNING WHEN "SIMILAR APPEARING" ADJACENT FOREST HAS BURNED? FIRE BEHAVIOR

719. 13 574 WHAT ARE THE EFFECTS OF FIRE ON SOIL AND VEGETATIVE COMPOSITION AFTER REPEATED BURNS ON THE KENAI PENINSULA - PARTICULARLY IN RELATION TO RE-ESTABLISHMENT OF MOOSE BROWSE? WILDLIFE,FIRE EFFECTS,SOIL,SHRUBLAND,TAIGA

720. 13 711 WHAT ARE THE RATES AND STAGES OF SUCCESSIONAL CHANGES WHICH FOLLOW FIRE IN BLACK SPRUCE FOREST? CAN WE DEVISE TECHNIQUES TO SPEED OR RETARD THESE SUCCESSIONAL STAGES TO SUIT DESIRED MANAGEMENT OBJECTIVES? SUCCESSION,FIRE EFFECTS,CONIFEROUS FOREST

721. 13 712 WE NEED THE ABILITY TO ACCURATELY PREDICT VEGETATIVE RESPONSE TO BURNS, INCLUDING PRESCRIBED BURNS. ALSO NEED THE ABILITY TO CONTROL OR REGULATE VEGETATIVE COVER OF SPECIFIC AREAS, ESPECIALLY IN CERTAIN KEY WILDLIFE AREAS. WE NEED THE ABILITY TO CREATE A FAVORABLE VEGETATIVE RESPONSE FOR BROWSE CONSUMING WILDLIFE SPECIES. WE NEED THE ABILITY TO CONDUCT PRESCRIBED BURNS ON SELECTED LANDS FOR WILDLIFE ENHANCEMENT. PRESCRIBED FIRE,SHRUBLAND,SHRUB UNDERSTORY,WILDLIFE,FIRE EFFECTS

722. 13 712 WHILE THIS IS PROBABLY BEYOND THE SCOPE OF YOUR DUTIES, THERE IS THE NEED TO OVERCOME THE "SMOKEY BEAR SYNDROME" THAT HAS BEEN DRUMMED INTO THE PUBLIC FOR SO MANY YEARS. NOT ALL FIRES ARE BAD, AND GENERALLY SPEAKING WILDFIRES (EXCEPT THOSE INVOLVING TREMENDOUS ACREAGES) ENHANCE WILDLIFE BY PRODUCING CERTAIN SHRUBS DURING VEGETATIVE SUCCESSION FOLLOWING FIRE THAT BROWSE CONSUMING WILDLIFE DEPEND UPON. INDEED, CERTAIN WILDLIFE SPECIES HAVE EVOLVED WHICH ARE DEPENDENT UPON CERTAIN STAGES OF VEGETATIVE SUCCESSION. MOOSE, DEER, HARES, SOME GROUSE, AND ELK ARE OUTSTANDING EXAMPLES OF WILDLIFE SPECIES WHICH ARE DEPENDENT UPON SHRUBS THAT DEVELOP DURING NATURAL SUCCESSION FOLLOWING FIRES. IN SOME INSTANCES, WILDLIFE VALUES MAY BE HIGHER THAN TIMBER, SCENIC OR OTHER VALUES. FIRE EFFECTS,FIRE EXCLUSION,TAIGA,WILDLIFE,PUBLIC REACTION,SUCCESSION,SMALL MAMMAL,GAME ANIMAL,HUMAN ECOLOGY

723. 13 737 WHAT IS THE IMPACT OF EXCLUDING FIRE IN INTERIOR ALASKA ON ANIMAL AND PLANT EVOLUTION? GENETIC RESPONSE,FIRE EXCLUSION,TAIGA

724. 13 738 ARE INSECT OUTBREAKS, FOLLOWING FIRES, NECESSARY TO MAINTAIN BIRDLIFE POPULATIONS - OR EVEN RELATED? INSECT,FIRE EFFECTS,BIRD

725. 13 738 ARE THERE KNOWN ECOLOGICAL EFFECTS OF WEATHER MODIFICATION IN RELATION TO FIRE MANAGEMENT? GENERAL FIRE MANAGEMENT,CLIMATE,HYDROLOGY,LIGHTNING EFFECTS

726. 13 738 AT WHAT BURN INTENSITY, OR TEMPERATURE, WILL ASPEN, BIRCH, AND WILLOW SEED BE KILLED? HOW LONG WILL HARDWOOD SEEDS REMAIN VIABLE IN DUFF OR IN OUR CASE THE ALASKA VEGETATIVE MAT? SEED,FIRE EFFECTS,HEAT EFFECTS,DECIDUOUS FOREST

727. 13 738 DO FOREST FIRES IN ALASKA INCREASE FINE FUELS OR DECREASE FINE FUELS AND WHAT HAPPENS TO SUBSEQUENT HAZARD AND RISK POTENTIALS? FIRE EFFECTS,FUEL REDUCTION,FLAMMABILITY,FUEL/BIOMASS ACCUMULATION

728. 13 738 IS MORE PROTEIN PRODUCED PER ACRE (ALSO FORAGE) AFTER FIRE? AT BASE-YEAR LEVEL? AT THE 5-YEAR LEVEL? AT THE 50 YEAR LEVEL? SHRUBLAND,WILDLIFE,GAME ANIMAL,FIRE EFFECTS,TAIGA,TUNDRA

729. 13 738 IS THERE A DEFINABLE STATISTICAL DIFFERENCE IN ECOLOGICAL EFFECT BETWEEN NATURALLY (LIGHTNING) CAUSED AND MAN-CAUSED FIRES? LIGHTNING-CAUSED FIRE,MAN-CAUSED FIRE,FIRE EFFECTS

730. 13 738 IT APPEARS THERE IS A DECIDEDLY DIFFERENT LONG-TERM EFFECT ON A TUNDRA AREA BURNED DURING THE LOW WATER TABLE YEARS THAN THE WETTER YEARS, EVEN THOUGH THE INITIAL REMOVAL OF THE TREES BY FIRE MAKES BOTH AREAS LOOK THE SAME IMMEDIATELY AFTER THE FIRE. FIRE EFFECTS,SOIL-WATER RELATIONS,TUNDRA

731. 13 738 WHAT ARE THE SHORT- AND LONG-RANGE PHYSICAL EFFECTS OF FIRE CONTROL ACTIVITIES IN ALASKA (TERRESTRIAL, WATER, PERMAFROST)? SUCH ACTIVITIES INCLUDE: CAT LINES, HAND LINES, USE OF ALL-TERRAIN VEHICLE TANKERS, FIRE RETARDANTS. PERMAFROST,SOIL-WATER RELATIONS,HUMAN DISTURBANCE,GENERAL FIRE MANAGEMENT,FIRE EXCLUSION

732. 13 738 WHAT IS THE EFFECT OF FIRE, WILDFIRE OR PLANNED BURNING, ON SONG BIRD POPULATIONS? WHEN WILL SONG BIRDS RETURN TO A BURN FOR NESTING, SEARCHING FOR FOOD, ETC.? BIRD,ANIMAL BEHAVIOR,FIRE EFFECTS

733. 13 738 WHAT IS THE EFFECT ON THE ENVIRONMENT OF DIFFERENT SNAG DENSITIES ON THE MELTING OF THE SNOW PACK IN SPRING? AFTER 5 YEARS? AFTER 50 YEARS? SNAG,FIRE EFFECTS,SNOW,MICROCLIMATE

734. 13 738 WHAT IS THE NORMAL PLANT SUCCESSION AFTER FIRE IN TAIGA, TUNDRA, ETC., TYPES ON VARIOUS SOILS? WHAT IS NORMAL PLANT SUCCESSION WITHOUT FIRES? WHAT IS THE BASE YEAR IMPACT ON WILDLIFE FROM BURNS IN THESE AREAS? WHAT IS THE 20-50 YEAR IMPACT? IS THE INITIAL LOSS OF HABITAT NECESSARY TO SUSTAIN THE 50-YEAR HABITAT? FIRE EFFECTS,TAIGA,TUNDRA,SUCCESSION,WILDLIFE,FIRE EXCLUSION

735. 14 308 CAN PRESCRIBED BURNING ENHANCE THOSE FACTORS IN PLANT SUCCESSION AND PLANT NUTRITION WHICH CREATE MORE FAVORABLE WINTER RANGE FOR UNGULATES, E.G. MOOSE, CARIBOU, ELK, MULE DEER? CAN BURNING ENHANCE THE PHYSICAL SUITABILITY OF WINTER RANGE, E.G. SNOW DISTRIBUTION AND DENSITY? GAME ANIMAL,SUCCESSION,NUTRIENTS

736. 14 309 HOW DO FIRE ALTERED ENVIRONMENTS, ESPECIALLY THE SIZE OF A BURN, AFFECT THE SPECIES AND DENSITIES OF BIRDS AND MAMMALS THAT OCCUR ON A BURN? AREA SIZE,SPECIES DIVERSITY,BIRD,SMALL MAMMAL,GAME ANIMAL

737. 14 309 WHAT IS THE ROLE OF BIRDS AND MAMMALS IN PREDISPOSING FORESTS TO FIRE AND SHAPING THE GROWTH OF NEW FORESTS AFTER A FIRE? BIRD,SMALL MAMMAL

738. 14 310 CAN SIMPLE TECHNIQUES USING AERIAL PHOTOGRAPHY BE DEVELOPED TO ASSESS THE VALUE OF FIRE SERES FOR NATIVE UNGULATE AND DOMESTIC UNGULATE RANGES IN NORTH CENTRAL BRITISH COLUMBIA? GAME ANIMAL,EXPERIMENT ORIENTED QUESTION

739. 14 310 WHY DO MOOSE IN NORTHERN BRITISH COLUMBIA MOVE TO MATURE FOREST FROM FOREST FIRE SERES IN JANUARY AND FEBRUARY? GAME ANIMAL

740. 14 311 HOW IS ARBOREAL LICHEN PRODUCTIVITY INFLUENCED BY FIRES OF DIFFERENT INTENSITY AND FREQUENCY? THIS QUESTION IS PERTINENT SINCE CURRENT RESEARCH DEMONSTRATES ARBOREAL LICHENS TO COMPRISE A SIGNIFICANT PORTION OF DEER AND ROOSEVELT ELK WINTER DIETS. THE QUESTION THUS COULD BE MORE BROADLY PHRASED TO ASK "HOW DO FIRE INTENSITY AND FREQUENCY INFLUENCE DEER AND ELK WINTER RANGE THROUGH THEIR INFLUENCES ON ARBOREAL LICHEN?" FIRES OF RELATIVELY LIGHT INTENSITY MAY BE CRITICAL UNDER SOME CONDITIONS WHEN LICHENS ARE EXTREMELY FLAMMABLE. I HAVE A POOR FEELING FOR THE FREQUENCY OF LIGHT FIRES IN BOREAL OR COASTAL FORESTS. EPIPHYTE,FIRE INTENSITY,FIRE FREQUENCY,GAME ANIMAL

741. 14 311 IN THE PACIFIC NORTHWEST: WHICH IMPORTANT WILDLIFE FORAGE SPECIES, IF ANY, ROOT SPROUT OR CROWN SPROUT AFTER FIRES OF SEARING INTENSITIES, E.G. GAULTHERIA SHALLON, VACCINIUM SPP.? ARE ANY OF THESE SPECIES ENCOURAGED BY FIRE OTHER THAN THROUGH OPENING OF THE FOREST CANOPY? FIRE INTENSITY,REPRODUCTION,SHRUB UNDERSTORY

742. 14 314 DOES SLASH BURNING REALLY PREVENT LONG-TERM BUILD-UP OF FOREST FLOOR FUELS IN A MANAGED FOREST? FUEL REDUCTION,FUEL/BIOMASS ACCUMULATION

743. 14 314 HOW DOES FIRE AFFECT INFILTRATION RATES? SOIL-WATER RELATIONS

744. 14 314 HOW DOES THE MICROCLIMATE OF A FOREST BURNT BY WILDFIRE COMPARE WITH THAT OF A CLEARCUT WHICH HAS BEEN SLASHBURNED? WHAT EFFECT DOES ANY DIFFERENCE HAVE ON ARTIFICIAL OR NATURAL REGENERATION? MICROCLIMATE,REPRODUCTION,MANIPULATION COMPARISON

745. 14 314 HOW EXTENSIVE IS HYDROPHOBICITY GENERATED BY FIRE? UNDER WHAT CONDITIONS DOES IT OCCUR? HOW LONG DOES IT LAST? WHAT LEADS TO ITS REDUCTION OVER TIME? SOIL-WATER RELATIONS

746. 14 314 TO WHAT EXTENT ARE DIFFERENT NUTRIENTS LOST BY VOLATILIZATION AND FLYASH DURING WILD OR PRESCRIBED FIRE? NUTRIENTS

747. 14 314 TO WHAT EXTENT CAN FIRE RESULT IN SERAL MICROCLIMATE BEING OUT OF PHASE WITH SERAL HUMUS CONDITION? MICROCLIMATE,DUFF,TIMING

748. 14 314 TO WHAT EXTENT DOES FIRE REDUCE ALLELOPATHIC SUBSTANCES OF MATERIALS INHIBITING SEED GERMINATION IN THE FOREST FLOOR? ALLELOPATHY,SEED

749. 14 314 WHAT IS THE EFFECT OF FIRE ON SEED EATING RODENTS? SMALL MAMMAL,SEED

750. 14 319 WHAT IS THE NATURAL FREQUENCY OF WILDFIRES AS REFLECTED IN THE DISTRIBUTION OF AGE CLASSES IN PRE-SETTLEMENT FOREST COVER? CAN THE EVIDENCE OF CLIMATIC VARIATIONS WHICH IS SHOWN IN TREE RINGS (WIDTHS OF, AND SPECIFIC GRAVITY PATTERNS WITHIN EARLYWOOD AND LATEWOOD) BE RELATED TO AGE STRUCTURE OF MATURE FORESTS TO INDICATE PROBABLE PAST FIRE DISTURBANCE PATTERNS? EXPERIMENT ORIENTED QUESTION,FIRE FREQUENCY

751. 14 332 IS FIRE EXCLUSION LIKELY TO PRESERVE INSECT-INFESTED OR DISEASE-INFESTED RESIDUAL TREES WHICH WILL FORM A SOURCE OF INFECTION TO THE SUCCEEDING STAND? IS FIRE EXCLUSION LIKELY TO ENHANCE THE ACCUMULATION OF DISEASE INOCULUM AND INSECT POPULATIONS? FIRE EXCLUSION,INSECT,DISEASE

752. 14 332 WHAT EFFECT DOES SMOKE HAVE ON THE VIABILITY OF AIR-BORNE INSECT AND SPORE POPULATIONS? SMOKE EFFECTS,INSECT,DISEASE,POPULATION

753. 14 332 WHAT WILL BE THE EFFECT OF CHANGING THE NATURAL FIRE FREQUENCY ON THE ESTABLISHMENT OF PLANTS WHICH ARE ALTERNATE HOSTS FOR TREE DISEASES? FIRE FREQUENCY,SUCCESSION,DISEASE,SHRUB UNDERSTORY

754. 14 332 WHAT WILL BE THE EFFECTS OF CONTROLLED BURNING ON STEM DECAY AND ROOT ROT DUE TO FUNGI GAINING ENTRY TO THE TREE THROUGH FIRE SCARS? PRESCRIBED FIRE,FUNGUS,DISEASE,STEM,ROOTS

755. 14 334 AT WHAT FREQUENCY AND VARIOUS FIRE INTENSITIES CAN ANY FOREST ECOSYSTEM BE BURNED WITHOUT DEGRADING THE SITE BEYOND WHAT IT STARTED OUT 100 YEARS PREVIOUS?
FIRE FREQUENCY,SUCCESSION,PRODUCTIVITY,FIRE INTENSITY

756. 14 334 CONSIDER EACH CLIMAX FOREST TYPE: DOES THE REPEATED BURNING OF A PRECLIMAX FOREST SYSTEM CAUSE CONTINUED REDUCTION OF THE NUTRIENT BANK? IF YES, HOW MUCH OF A NUTRIENT REDUCTION, AND WHAT FIRE FREQUENCY, MUST OCCUR TO KEEP THE SYSTEM AT EACH SERAL STAGE (CONSIDER ALL STRATA OF THE FOREST SYSTEM)?
NUTRIENTS,SUCCESSION,FIRE FREQUENCY

757. 14 334 DESCRIBE THE MOVEMENT OF MICRONUTRIENTS AFTER FIRE IN ALL SOIL TYPES, AT ALL ELEVATIONS, ON ALL ASPECTS AND AT ALL SLOPE ANGLES. NUTRIENTS,SOIL

758. 14 334 HOW MANY 100 YEAR ROTATIONS OF LOGGING AND SLASH BURNING CAN EACH FOREST TYPE HAVE WITHOUT DEGRADING THE SITE BEYOND WHAT IT STARTED OUT 100 YEARS PREVIOUS?
FUEL REDUCTION,FIRE FREQUENCY,PRODUCTIVITY,FIRE INTENSITY

759. 14 334 HOW MUCH ORGANIC SOIL REDUCTION WILL RESULT FROM FIRES BURNING THROUGH VARIOUS FUEL COMPLEXES IN RELATION TO CODES OF THE NATIONAL FIRE WEATHER INDEX? FUEL REDUCTION,SOIL

760. 14 334 THE INTENSE HEAT OF SOME FOREST FIRES CAUSES SOME ROCK TO SCALE AND CRACK: THE ASH LEFT ON SOME ROCK REACTS WITH COMPOUNDS AND RESULTS IN ACCELERATED DECOMPOSITION. WHAT IS THE RATE OF ROCK DECOMPOSITION AFTER FIRES OF VARIOUS INTENSITIES AND VARIOUS FREQUENCIES? HEAT EFFECTS,FIRE
INTENSITY,ROCK,NUTRIENTS,ASH

761. 14 334 WHAT ARE THE BENEFICIAL EFFECTS OF FIRE BURNING ON RIDGES, MOUNTAIN TOPS AND SIDE HILLS IN RELATION TO AGRICULTURE LANDS DOWN SLOPE? MOSAIC,ZONATION,ECONOMIC EFFECTS

762. 14 334 WHAT IS THE RELATIONSHIP BETWEEN ENERGY RELEASE RATE PER AREA AND NUTRIENT LOSS INTO THE SMOKE COLUMN? WHAT ARE THE LOSS RATES OF NUTRIENTS FROM THE TOTAL NUTRIENT BANK DURING FIRES OF VARIOUS ENERGY RELEASE RATES PER AREA? WHAT MICRONUTRIENTS ARE CARRIED INTO THE SMOKE COLUMN? HOW FAR ARE NUTRIENTS CARRIED BY SMOKE UNDER VARIOUS ATMOSPHERIC CONDITIONS?
NUTRIENTS,SMOKE EFFECTS,FIRE INTENSITY,DISPERSION

763. 14 334 WHAT PERCENTAGE OF THE TOTAL NUTRIENT BANK IS MADE AVAILIBLE TO PLANTS AFTER FIRES OF DIFFERENT INTENSITIES, AND FUEL LOADINGS?
NUTRIENTS,VEGETATION,FIRE INTENSITY,FUEL/BIOMASS ACCUMULATION

764. 14 334 WHAT PERCENTAGE OF THE TOTAL NUTRIENT BANK IS TIED-UP BY MICROBES AND FUNGAL ACTIVITY AFTER FIRES OF DIFFERENT INTENSITIES, AND FUEL LOADINGS?
NUTRIENTS,MICROORGANISM,FIRE INTENSITY,FUEL/BIOMASS ACCUMULATION

765. 14 335 WHAT RANGES OF FIRE BEHAVIOR ARE NORMALLY EXPERIENCED, IN HIGH ELEVATION ENGELMANN SPRUCE-SUBALPINE FIR ALPINE TRANSITION FORESTS AS DEPENDENT ON ELEVATION, INDICATORS OF DROUGHT, WIND VELOCITY, STATE OF CURE OF LESSER VEGETATION? IS FIRE BEHAVIOR ADEQUATELY PREDICTABLE IN THESE HIGH ELEVATION ECOSYSTEMS TO INSURE ACHIEVEMENT OF DESIRED ECOLOGICAL EFFECTS OF LIMITING FIRE SUPPRESSION, AS WELL AS ENSURING PUBLIC SAFETY IN AREAS OF PUBLIC USE WHERE LIMITED FIRE SUPPRESSION IS PRACTICED? WHAT RANGES OF FIRE BEHAVIOR ARE EFFECTIVE IN CHANGING SUCCESSIONAL STAGE IN ALPINE TRANSITION ZONES, WHAT CYCLE LENGTHS ARE INVOLVED IN SUBALPINE SUCCESSIONAL STAGES, AND WHAT IS NORMAL FIRE PERIODICITY IN HIGH ELEVATION SUBALPINE AND ALPINE TYPES IN THE MOUNTAIN WEST? FIRE BEHAVIOR,SUCCESSION,ZONATION

766. 14 336 IN WHITE OR ENGELMANN SPRUCE/ALPINE FIR FORESTS - PARTICULARLY THOSE WITH SOILS OF RELATIVELY LOW NUTRIENT STATUS - WILL SLASH BURNING, AFTER LOGGING FOR HAZARD REDUCTION OR SITE PREPARATION, REDUCE THE FERTILITY (PRODUCTIVITY) OF THE SITE AFTER SEVERAL ROTATIONS, EVEN IF NOT DURING THE FIRST ROTATION AFTER LOGGING THE MATURE STAND? NUTRIENTS,FIRE FREQUENCY,PRODUCTIVITY,PRESCRIBED FIRE,FUEL REDUCTION

767. 14 336 IS FIRE LESS DELETERIOUS THAN CURRENT FORMS OF MECHANICAL SITE PREPARATION FOR HAZARD REDUCTION OR SITE PREPARATION? MANIPULATION COMPARISON,FUEL REDUCTION

768. 14 336 WHAT IS THE EFFECT ON SUBSEQUENT TREE CROP PRODUCTIVITY-UP TO SEVERAL GENERATIONS-OF REDUCTION IN DEPTH OF THE L-F-H LAYER BY BURNING ON VARIOUS TYPES OF SITES - NUTRIENT POOR, NUTRIENT RICH, SHALLOW OR DEEP L-F-H: CONSEQUENTLY ON WHICH SITES CAN WHAT INTENSITY OF PRESCRIBED BURNING BE RECOMMENDED?
LITTER,NUTRIENTS,FUEL REDUCTION,FIRE FREQUENCY,PRODUCTIVITY

769. 14 338 THE NORTHERN BOREAL FOREST AREAS CHARACTERIZED BY CLADONIA GROUND COVER NORMALLY EXPERIENCE FEW RELATIVELY SHORT PERIODS CONDUCIVE TO FIRE PROPAGATIONS. THE RAPID RESPONSE OF FIRE-RELATED NATURAL PHENOMENA WOULD SEEM TO INDICATE THAT RELATIVELY FEW, VERY LARGE FIRES ARE A NECESSARY COMPONENT OF THE NORTHERN BOREAL FOREST: CONSIDER- A) THE RAPID DRYING OF CLADONIA MOSS AND THE MINIMAL UPPER PORTION THAT MUST BE AVAILABLE TO SUPPORT COMBUSTION. B) THE CONTINUOUS NATURE OF THIS FUEL TYPE COMBINED WITH A FULLY INTEGRATED EXTREMELY FLAMMABLE (SPRUCE-FIR) AERIAL FUEL COMPONENT THAT PROVIDES RAPID TRANSITION TO THE CROWNING STAGE IN A FUEL TYPE (TRUE FIR) NOTED FOR FIRE BRAND INITIATION. THE EASE OF CLADONIA MOSS IGNITION, ENSURES A HIGH IGNITION

PROBABILITY UPON CONTACT. C) THE COINCIDENCE OF WEATHER SYSTEMS (HUDSON BAY HIGH) THAT INVOLVE A COMBINATION OF SUSTAINED HIGH WINDS AND SEVERE DRYING THAT COINCIDE WITH A PERIOD WHEN FOLIAR FLUSHING, AND FROZEN SOILS MAY RESULT IN SEVERE DEPRESSION OF FOLIAR MOISTURE CONTENT. THE COMBINATION OF WEATHER AND THE PECULIARITIES OF THE FUEL COMPLEX INDICATE A NATURAL SYSTEM THAT INSURES MAXIMUM BURNED AREA IN THE SHORT TIME AVAILABLE. IF THESE CIRCUMSTANCES ARE NOT COINCIDENTAL THEN THE VERY COSTLY FIRE CONTROL EFFORT ON NATURAL CAUSED FIRES MUST BE DETRIMENTAL TO THIS ECOSYSTEM AND THE CLADONIA MOSS COMMUNITIES. WHAT THEN IS THE RELATIONSHIP BETWEEN CLADONIA COMMUNITIES, CARIBOU AND FIRE? CUSHION PLANTS,FIRE BEHAVIOR,AREA SIZE,CROWN BURN,CLIMATE,SOIL-WATER RELATIONS,FIRE EXCLUSION,GAME ANIMAL

770. 14 758 WHAT ARE THE EFFECTS OF BURNING A CLIMAX FOREST AS COMPARED TO A SECOND GROWTH FOREST OR A LOGGED-OVER CLEARCUT IN TERMS OF RESULTING PLANT COMMUNITIES AND SOIL DEVELOPMENT? TO WHAT EXTENT DO FIRES BURN IN CLIMAX FORESTS WITHOUT ALTERING THE BASIC CHARACTER OF THE FOREST? IN OTHER WORDS CAN A FIRE BURN IN A MATURE FOREST WITHOUT DESTROYING THAT FOREST? FIRE EFFECTS,SUCCESSION,MANIPULATION COMPARISON,COMMUNITY

771. 14 758 WHAT ARE THE EFFECTS OF TIMING (SEASON) AND FIRE INTENSITY, ON THE SUCCESSIONAL STAGES THAT DEVELOP AFTER A FOREST FIRE? WE ARE CONCERNED WITH DOUGLAS-FIR FORESTS BUT ALSO TO A LESSER DEGREE PONDEROSA PINE FORESTS, WESTERN LARCH FORESTS, SPRUCE AND FIR FORESTS. THE REASON FOR THIS QUESTION IS IN SOME AREAS A DOUGLAS-FIR FOREST REGENERATES TO LODGEPOLE PINE OR TO ASPEN OR TO WILLOW. WHAT CAUSES THESE DIFFERENT SERAL COMMUNITIES? IS IT FIRE INTENSITY, SEASON OF THE BURN, SOIL CONDITION OR THE TYPE OF FOREST? FIRE INTENSITY,TIMING,SOIL,FIRE EFFECTS,SUCCESSION,CONIFEROUS FOREST

772. 14 758 WHAT ARE THE SIMILARITIES AND DIFFERENCES BETWEEN A CLEARCUT LOGGING OPERATION AND A FOREST FIRE ON AREAS OF THE SAME SIZE? WE ARE INTERESTED IN SOIL PROPERTIES SUCH AS MOISTURE HOLDING CAPACITY, ORGANIC MATTER, CARBON:NITROGEN RATIO, CALCIUM:PHOSPHOROUS RATIO, CHANGES IN THE CHEMICAL PROPERTIES OF STREAMS, AND RESULTING PLANT COMMUNITY DEVELOPMENT. HUMAN DISTURBANCE,MANIPULATION COMPARISON,SOIL-WATER RELATIONS,COMPOUNDS,ELEMENTS,STREAM,CONIFEROUS FOREST,FIRE EFFECTS

773. 14 758 WHAT EFFECTS DO FOREST FIRES HAVE ON THE CHEMICAL CONTENT OF STREAMS, BOTH IN THE AREA OF THE FIRE AND DOWNSTREAM? WHAT EFFECT DO FOREST FIRES HAVE ON SEDIMENT DEPOSITS IN THE STREAM? CONSIDER THINGS SUCH AS FLY-ASH AND SOIL. STREAM,FIRE EFFECTS,ASH,SOIL EROSION

774. 14 759 CAN GUIDELINES AND TECHNIQUES BE CREATED FOR CONTROLLED BURNING OF NON-MERCHANTABLE FORESTS FOR WILDLIFE? GENERAL FIRE MANAGEMENT,ANIMALS

775. 14 759 HOW CAN FIRE ELIMINATE, OR PROMOTE, FOREST PATHOGENS AND DESTRUCTIVE, OR BENEFICIAL (E.G. FISH FOOD), INSECT POPULATIONS? DISEASE,INSECT,POPULATION

776. 14 759 HOW DO DIFFERENT INTENSITY BURNS AFFECT SOIL NUTRIENTS, E.G. WHAT PERCENTAGES OF MINERAL SOIL AND ORGANIC MATTER ARE LOST? WHAT IS THE AFFECT ON GROWING SITE? FIRE INTENSITY,NUTRIENTS,FUEL REDUCTION,SOIL

777. 14 759 HOW DO RECURRING BURNS AFFECT SEED SOURCE? FIRE FREQUENCY,SEED,REPRODUCTION

778. 14 759 HOW DOES THE CONSUMPTION OF FUELS (E.G. IMMATURE CONIFERS AFTER SPRING FLUSHING VERSUS DORMANT DECIDUOUS VEGETATION OR, GREEN SLASH VERSUS CURED SLASH) AFFECT SOILS AND WATER QUALITY? FUEL REDUCTION,NUTRIENTS,SOIL,HYDROLOGY

779. 14 759 UNDER WHAT CONDITIONS DO CONIFEROUS STANDS BURN BUT DECIDUOUS STANDS NOT IGNITE (AND VICE VERSA)? FLAMMABILITY,CONIFEROUS FOREST,DECIDUOUS FOREST

780. 14 759 WHAT ARE THE ECONOMICS OF FIRE SUPPRESSION IN NON-COMMERCIAL STANDS: RATING BENEFITS OF SUPPRESSION VERSUS BENEFIT TO WILDLIFE GAINED BY LEAVING SUCH FIRES TO BURN? ECONOMIC EFFECTS,FIRE EXCLUSION,ANIMALS

781. 14 759 WHAT ARE THE EFFECTS UPON WATER AND SOIL, OF DIFFERENT FIRE SUPPRESSION TECHNIQUES, E.G. PERMANENT RETARDANT APPLICATION? CHEMICAL RETARDANT EFFECTS,NUTRIENTS,SOIL

782. 14 759 WHAT ARE THE IMMEDIATE AND LONG TERM IMPACTS UPON WATER QUALITY FROM DIFFERENT INTENSITY BURNS, ESPECIALLY FROM HOT BURNS ADJACENT TO WATER BODIES? AQUATIC,NUTRIENTS,HYDROLOGY,FIRE INTENSITY,AREA SIZE,MOSAIC

783. 14 759 WHAT DEER AND MOOSE BROWSE-SPECIES REGENERATE BEST AFTER BURNING: HOW DOES THE INTENSITY OF BURN AFFECT REGENERATION? FIRE INTENSITY,GAME ANIMAL,REPRODUCTION,HERBIVORY

784. 14 759 WHAT INTENSITIES OF GROUND-FIRE CAN BE TOLERATED BY DIFFERENT UNDERSTORY AND OVERSTORY SPECIES? FIRE INTENSITY,HERBAGE UNDERSTORY,SHRUB UNDERSTORY,CONIFEROUS FOREST,GROUND FIRE

785. 14 762 DOES ASH IN CREEK AND POND BOTTOMS HAVE A POSITIVE OR NEGATIVE EFFECT UPON INVERTEBRATES? ASH,FIRE EFFECTS,STREAM,LAKE

786. 14 762 DURING A FIRE IS OXYGEN ABSTRACTED FROM PONDS OR RUNNING WATER? IF A FIRE PASSES OVER OR BY A STREAM OR POND WHICH HAS A LOW DISSOLVED OXYGEN CONCENTRATION CAN THIS CONCENTRATION BE LOWERED BY THE FIRES' DEMAND FOR OXYGEN? STREAM,LAKE,FIRE EFFECTS,MICROCLIMATE

787. 14 762 HOW FAR DOWNSTREAM DOES THE CARBONIFEROUS WASTE MATERIAL TRAVEL? IS THIS DISTANCE A FUCTION OF TIME,

GRADIENT, TEMPERATIURE? IN A 3% STREAM GRADIENT WILL THE DEBRIS EFFECTS BE FELT DOWNSTREAM? IF SO, HOW FAR? WILL IT FLUSH IN ONE YEAR? STREAM,CHARCOAL,ASH,FIRE EFFECTS

788. 14 767 CAN ONE PREDICT POST-FIRE SUCCESSION, KNOWING ORIGINAL VEGETATION AND CHARACTERISTICS OF FIRE (INTENSITY, ENERGY RELEASED, TYPE, ETC.)? SUCCESSION,FIRE EFFECTS,FIRE INTENSITY,FIRE BEHAVIOR

789. 14 767 COULD LODGEPOLE PINE STANDS BE CONVERTED TO SOME MORE USEFUL TYPE OF VEGETATION BY REPEATED BURNING AND RESEEDING? FIRE EFFECTS,FIRE FREQUENCY,CONIFEROUS FOREST,HUMAN DISTURBANCE

790. 14 767 DO FIRES ON WETTER TIMBER SITES LEAD TO PALUDIFICATION? SOIL-WATER RELATIONS,CONIFEROUS FOREST,FIRE EFFECTS

791. 14 767 DOES VEGETATION OF POST-FIRE COMMUNITIES DIFFER FROM POST-LOGGING COMMUNITIES WITH RESPECT TO CHEMICAL COMPOSITION OF THE SAME PLANT SPECIES. SUCCESSION,HUMAN DISTURBANCE,COMPOUNDS,ELEMENTS,FIRE EFFECTS,ALLELOPATHY

792. 14 767 HOW HAS/DOES FIRE EXCLUSION AFFECTED/AFFECT THE SPECIES COMPOSITION, ABUNDANCE, AND NUTRITIONAL QUALITY OF THE UNDERSTORY OF THE DOUGLAS-FIR ZONE IN INTERIOR BRITISH COLUMBIA? (WE ARE ESPECIALLY CONCERNED WITH WILLOW AND AMELANCHIER SPECIES WHICH SEEM TO DECLINE BOTH IN QUALITY AND QUANTITY WHEN FIRE IS EXCLUDED). FIRE EXCLUSION,SHRUB UNDERSTORY,SPECIES DIVERSITY,NUTRIENTS,DECIDUOUS FOREST,CONIFEROUS FOREST

793. 14 767 HOW VARIABLE IS A FIRE IN ITS EFFECTS ON A RELATIVELY HOMOGENEOUS AREA? FIRE EFFECTS,FIRE BEHAVIOR

794. 14 767 WHAT ARE ACTUAL LOSSES OF WILDLIFE DUE TO FIRE, WHEN CONSIDERED OVER LONG TIME PERIODS? FIRE EFFECTS,ANIMAL BEHAVIOR,MORTALITY,WILDLIFE

795. 14 767 WHAT ARE EFFECTS OF FIRE ON SOIL MICROORGANISMS? FIRE EFFECTS,SOIL,MICROORGANISM

796. 14 767 WHAT ARE LONG-TERM CONSEQUENCES OF REPEATED FIRES ON A SITE, I.E. IS A SITE DEGRADED, IS THERE A SPACING (TIME-WISE) OF FIRE THAT IS CRITICAL? (THINKING OF REPEATEDLY BURNED LODGEPOLE PINE AREAS) FIRE EFFECTS,TIMING,FIRE FREQUENCY,CONIFEROUS FOREST

797. 14 767 WHAT ARE MAJOR DIFFERENCES BETWEEN PRESCRIBED AND WILDFIRES? PRESCRIBED FIRE,MAN-CAUSED FIRE,LIGHTNING-CAUSED FIRE,FIRE EFFECTS

798. 14 767 WHAT ARE THE MECHANISMS EVOLVED BY CONIFEROUS FORESTS TO PROTECT THEMSELVES AGAINST FIRE? HOW ARE THESE AFFECTED BY FIRE EXCLUSION? GENETIC RESPONSE,FIRE EFFECTS,FLAMMABILITY,FIRE EXCLUSION,CONIFEROUS FOREST

799. 14 767 WHAT ARE THE SPECIFIC CHANGES IN SUSCEPTIBILITY TO FIRE WITH AGING OF THE FOREST IN VARIOUS PLANT ASSOCIATIONS? THIS IS IMPORTANT BECAUSE WE NEED TO KNOW HOW VULNERABLE WILDLIFE RESERVE AREAS WILL BE. IT IS PERTINENT TO SELECTING AREAS FOR CARIBOU WINTER RANGE TO BE RESERVED FROM LOGGING. FLAMMABILITY,AGE,WILDLIFE

800. 14 767 WHAT ARE THE TOTAL COSTS OF FIRE FIGHTING WITH DIFFERENT METHODS? BULLDOZED FIREGUARDS ARE A MAJOR CONTRIBUTING FACTOR TO EROSION IN MANY OF OUR MOUNTAINOUS AREAS. THEY CREATE HIGH SILT LOADS IN FEEDER STREAMS AND USUALLY RETARD SUCCESSION TO ITS VERY EARLIEST STAGE. AESTHETIC LOSSES ARE OFTEN CONSIDERABLE BECAUSE FIREGUARDS ARE CONSTRUCTED QUICKLY TO STOP FIRES AND NO CONSIDERATION IS GIVEN TO THE EFFECTS OF LANDSCAPE SCARRING. IT APPEARS THAT THERE IS A GOOD OPPORTUNITY TO DO COST BENEFIT ANALYSES HERE THAT MAY LEAD TO MORE SPARING USE OF FIREGUARDS IN CONTROLLING FOREST FIRES. ECONOMIC EFFECTS,FIRE EXCLUSION,SUCCESSION,HUMAN DISTURBANCE,SOIL EROSION,AESTHETICS

801. 14 767 WHAT IS THE RELATIONSHIP OF FIRE SIZE AND FIRE INTENSITY TO THE TYPE OF REVEGETATION ON BURNED CONIFEROUS STANDS? (AT WHAT SIZE BURN DOES SEED WEIGHT BECOME AN IMPORTANT FACTOR?) AREA SIZE,FIRE INTENSITY,SEED,DISPERSION,CONIFEROUS FOREST,ORGAN

802. 14 767 WHAT WAS THE "NATURAL" PATTERN OF FIRE IN VARIOUS BIOGEOCLIMATIC ZONES HAVING CONIFEROUS FORESTS? IT IS IMPORTANT TO INVESTIGATE THIS VERY SOON BECAUSE MANY OF THESE ZONES ARE BEING LOGGED SO QUICKLY THAT THERE WON'T BE ENOUGH AREA IN WHICH TO WORK. FIRE HISTORY,FIRE EFFECTS,MICROCLIMATE,HUMAN DISTURBANCE,MOSAIC

803. 14 767 WHAT WOULD BE THE ECOLOGIC CONSEQUENCES OF TRYING TO PERPETUATE DECIDUOUS SUB CLIMAX STANDS IN AN AREA WHERE CONIFERS MAKE UP THE CLIMAX FOREST? SUCCESSION,DECIDUOUS FOREST,CONIFEROUS FOREST

804. 14 791 IN BROADCAST SLASH BURNING OF HEAVY RESIDUES SUCH AS THOSE ENCOUNTERED IN B.C. INTERIOR WET BELT CEDAR-HEMLOCK STANDS, WHAT IS THE EFFECT ON THE PHYSICAL AND CHEMICAL PROPERTIES OF VARIOUS SOILS IN RESPECT TO SECURING NATURAL AND ARTIFICIAL CONIFEROUS REGENERATION? IS TOO MUCH EMPHASIS PLACED ON HAZARD REDUCTION IN BROADCAST SLASH BURNING RATHER THAN MAINTENANCE OF AVAILABLE NUTRIENT FOR FOREST REGENERATION? THIS APPLIES TO PRESCRIBED BROADCAST BURNING ON DIFFERENT SITE TYPES, NOT ONLY CEDAR-HEMLOCK. PRESCRIBED FIRE,FUEL REDUCTION,SOIL,NUTRIENTS,CONIFEROUS FOREST,REPRODUCTION,FIRE EFFECTS

805. 14 798 A LARGE PORTION OF THE SURROUNDING AREA IS COVERED BY BLACK SPRUCE GROWING ON MUSKEG SITES OFTEN ASSOCIATED WITH PERMAFROST. MUCH OF THE AREA HAS BEEN REPEATEDLY BURNED. DOES FREQUENT BURNING OF THIS TYPE OF FOREST TEND TO PROLONG THE WET STATE BECAUSE OF THE LOSS OF THE MOISTURE REMOVING EFFECTS OF TRANSPIRATION? WOULD

LONG-TERM TOTAL EXCLUSION OF FIRE FROM BLACK SPRUCE FOREST ON MUSKEG SITES WITH PERMAFROST TEND TO PROMOTE DRYING OF THE SITE THROUGH INCREASED TRANSPIRATION BY THE ADDED FOREST COVER, OR WOULD THE RATE OF EVAPORATION FROM THE SAME SITE IN A FIRE-DENUDED STATE EXCEED MOISTURE LOSS BY TRANSPIRATION? FIRE EXCLUSION,FIRE EFFECTS,TAIGA,PERMAFROST,SOIL-WATER RELATIONS,MICROCLIMATE

806. 14 799 CAN PRESCRIBED BURNING REDUCE WATER EVAPORATION BY TREES, PARTICULARLY DECIDUOUS, THEREBY INCREASING SUMMER WATER LEVELS? IF SO, WHAT WOULD BE THE MAXIMUM REMOVAL ALLOWED? PRESCRIBED FIRE,HYDROLOGY

807. 14 799 DEPENDENT UPON TIMBER TYPES, SOILS AND SLOPES, SHOULD AREAS RECOMMENDED FOR SLASH BURNING BE SUMMER OR WINTER LOGGED? FUEL REDUCTION,TIMING

808. 14 799 DOES A BURNED OPENING IN CONIFEROUS FOREST INCREASE GOOD GRASSES FOR RANGE CATTLE, OR DOES IT BRING ON FAST SPREADING WEEDS? AREA SIZE,SUCCESSION,COMPETITION

809. 14 799 DOES SLASH BURNING CREATE ASH PROBLEMS IN STREAMS, IF SO, IS THE ASH HARMFUL TO FISH? FUEL REDUCTION,ASH,STREAM,FISH

810. 14 799 DOES THE LIVING FOREST COMMUNITY REQUIRE A FREE RUNNING GROUND FIRE IN ORDER TO STAY THRIFTY AND HEALTHY, OR IS IT ONLY A REDUCTION IN FIRE HAZARD? IN SHORT, DOES ONE REASON OUTWEIGH THE OTHER? GROUND FIRE,PRODUCTIVITY, FUEL REDUCTION

811. 14 799 THE EFFECTS OF SUMMER VS. WINTER LOGGING ON SCARIFICATION AND REGENERATION, PARTICULARILY IN LODGEPOLE PINE STANDS WHERE THERE IS OFTEN ONLY 2-4 INCHES OF LIGHT SOIL ON GRAVEL: DOES SUMMER WHOLE-TREE SKIDDING CREATE TOO MUCH DISTURBANCE ON THESE LOOSE SOILS? WE HAVE NOTED ON SOME HILLSIDES THAT THERE IS THIN SOIL. SHOULD THESE AREAS BE WINTER LOGGED?--WITH WHOLE TREES REMOVED AND TOPS BURNED AT THE LANDINGS WILL THERE BE SUFFICIENT NUTRIENTS LEFT TO BRING THE NEW CROP TO HARVEST OR WILL IT STAGNATE AFTER 20 OR 30 YEARS?--SHOULD THE TOPS BE LEFT AND WALKED OR ROLLED DOWN WITH HEAVY EQUIPMENT? WHAT TYPE OF EQUIPMENT ACHIEVES MAXIMUM DESIRED RESULTS? FIRE INTENSITY,NUTRIENTS,PRODUCTIVITY,PRESCRIBED FIRE,STABILITY,SOIL,REPRODUCTION,MANIPULATION COMPARISON,FUEL REDUCTION,DECOMPOSITION

812. 14 799 HOW FAR DOWNSTREAM DO LARGE SLASH BURNS AFFECT STREAMS IN SILTATION, TEMPERATURES AND OTHERS BEFORE THE STREAMS FILTER THEMSELVES OUT? IS THERE SUCH A THING AS AN OPTIMUM SIZE FOR ANY GIVEN BURN UNDER VARIOUS CONDITIONS? AREA SIZE,STREAM,SOIL EROSION

813. 14 799 HOW LARGE CAN A BURNED OPENING BE BEFORE THERE IS ANY SERIOUS AFFECT ON THE STREAM FLOW AND SUBTERRANEAN WATER LEVELS DURING RUN-OFFS AND SUMMER DROUGHTS? AREA SIZE,HYDROLOGY

814. 14 799 IN FREE RUNNING GROUND FIRES, ARE THERE ANY BENEFICIAL RESULTS TO FOREST GROWTH? EXPERIMENT ORIENTED QUESTION,GROUND FIRE,PRODUCTIVITY

815. 14 799 IS THERE AN INCREASE OR DECREASE IN SMALLER WILDLIFE IN 2-5 YEARS AFTER BURNING AS AGAINST THE OTHER TREATMENTS? ANIMALS,TIMING,POPULATION,PRODUCTIVITY

816. 14 799 IS THERE ANY APPRECIABLE CHANGE IN NEW CROPS AS TO HEALTH AND VIGOR IN BURNS AS COMPARED TO OTHER TREATMENTS? DO BURNS DESTROY SOME PATHOLOGICAL DISEASES AND INCREASE OTHERS? DISEASE,MANIPULATION COMPARISON

817. 14 799 ON LIGHT SOILS, DOES SLASH BURNING LEAVE SUFFICIENT NUTRIENTS TO ALLOW THE NEXT TREE CROP TO PRODUCE BIOMASS AT THE SAME RATE AS THE HARVESTED CROPS? FUEL REDUCTION,NUTRIENTS,REPRODUCTION,FUEL/BIOMASS ACCUMULATION

818. 14 799 SHOULD BURNED OPENINGS IN CONIFEROUS FORESTS BE SOWN TO GRASSES IN ORDER TO CURTAIL AN EXCESS OF REGENERATION IN SOME PINE AND LARCH AREAS? PLANTING,SOIL EROSION,HYDROLOGY

819. 14 799 SHOULD INITIAL PRESCRIBED BURNING BE AT THE HIGHER ELEVATION FIRST, THEREBY PERHAPS ALLOWING THE LOWER COVER TO FILTER OUT EROSION AND ABSORB EXCESS RUN-OFFS INTO STREAMS? PRESCRIBED FIRE,ZONATION,SOIL EROSION,STREAM

820. 14 799 SHOULD PRESCRIBED CROWN-FIRE AREAS IN MOUNTAINOUS TERRAIN BE CROSS VALLEY OR PARALLEL? SHOULD THEY BE CONTOUR ON HILLSIDES? ALL OF THESE OPENINGS HAVE DECIDEDLY DIFFERENT IMPACTS ON STREAM FLOW, TEMPERATURE, SILTATION, WILDLIFE COVER AND AQUATIC LIFE. PRESCRIBED FIRE,MOSAIC,TOPOGRAPHY,HYDROLOGY,MICROCLIMATE,ANIMALS,SOIL EROSION

821. 14 799 WHAT DIFFERENCE IS THERE IN DAY/NIGHT HUMIDITIES AND RECOVERY BETWEEN BURNED OPENINGS AND ADJACENT FOREST COVER? MICROCLIMATE

822. 14 799 WHAT IS THE HEAT INCREASE IN STREAM TEMPERATURES AFTER BURNING OFF COVER TO THE BANKS AND WHAT WOULD BE THE MAXIMUM DISTANCE ALLOWED BEFORE THIS TAKES PLACE? (STREAM VOLUME AND SPEED OF FLOW WILL ALSO BE DECIDING FACTORS) STREAM,MICROCLIMATE,VEGETATION

823. 14 799 WHAT IS THE SUMMER HEAT INCREASE ON BLACKENED AREAS AS COMPARED TO UNBURNED SLASH AND THE BLOCKS OF TIMBER LEFT? WHAT ARE THE COMPARISONS IN HUMIDITIES, IN WATER LEVELS, IN NATURAL REGENERATION, IN SNOW MELT? FUEL REDUCTION,MANIPULATION COMPARISON,MICROCLIMATE,REPRODUCTION,HYDROLOGY

824. 14 799 WITH PRESCRIBED GROUND FIRE, HOW MUCH MORTALITY IS THERE ON CONIFEROUS SPECIES AND HOW MANY WILL BECOME CAT-FACED AND FIRE SCARRED? WHAT IS THE RECOVERY PERIOD IN VARIOUS TIMBER TYPES? EXPERIMENT ORIENTED QUESTION,GROUND FIRE,MORTALITY

825. 14 799 WITH SLASH BURNING AFTER LOGGING, IS THERE AN INCREASE OR DECREASE IN EROSION AS COMPARED TO SCARIFICATION? FUEL REDUCTION,MANIPULATION COMPARISON,SOIL EROSION,

826. 14 801 CURRENTLY WE ARE FACED WITH UNFAVORABLE PUBLIC REACTION TO SMOKE POLLUTION FROM SLASH BURNING. "SMOKE MANAGEMENT" IS NOT SUCCESSFUL TO A LARGE ENOUGH DEGREE AND WE ARE LOOKING AT A "SMOKELESS" ENVIRONMENT FOR THE FUTURE - BY POPULAR DEMAND. AIR POLLUTION,VALUE JUDGEMENT,PUBLIC REACTION,AESTHETICS,FUEL REDUCTION,PRESCRIBED FIRE

827. 14 801 IS SMOKE AN ECOLOGICAL NECESSITY FOR A BALANCED ATMOSPHERIC CONDITION IN THE LONG PULL? MICROCLIMATE,SMOKE EFFECTS

828. 14 801 THIS YEAR, IN ONE FOREST DISTRICT, OVER 1,000 FIRES WERE EXTINGUISHED IN THE INCIPIENT STAGES. WHILE 80% OF THESE WERE HUMAN-CAUSED, AND NOT PART OF THE NATURAL CYCLE, 200 LIGHTNING FIRES COULD HAVE BURNED THOUSANDS OF ACRES IF LEFT ALONE. WHAT EFFECTS DOES THIS FIRE EXCLUSION MANIPULATION HAVE ON ALL ASPECTS OF THE ECOLOGICAL SCENE? SMOKE AND ASH NUTRIENTS LOST? SUCCESSION CROPS NOT REPLACING DECADENT STANDS AND SOIL NUTRIENTS NOT REPLENISHED THROUGH NATURAL CROP ROTATIONS? INCREASING SCARCITY OF BROWSE FOR UNGULATE RANGE? FIRE EXCLUSION,FIRE EFFECTS,WILDLIFE,NUTRIENTS,ASH,SUCCESSION,SPECIES DIVERSITY

829. 15 320 WHAT ARE THE LONG AND SHORT-TERM EFFECTS OF FOREST FIRES ON THE NUTRIENT LEVELS IN MOUNTAIN LAKES? IS PRODUCTIVITY AFFECTED SIGNIFICANTLY? WHAT CHANGES OCCUR IN THE PLANKTONIC, BENTHIC, AND SHORELINE COMMUNITIES? WHAT CHANGES OCCUR IN THE INPUT OF TERRESTRIAL INSECTS WHICH WOULD SERVE AS IMPORTED FISH-FOOD ORGANISMS? FIRE EFFECTS,FISH,NUTRIENTS,LAKE,MOUNTAIN,INSECT,ECOSYSTEM,PRODUCTIVITY

830. 15 323 ARE THE RELATIVE FLAMMABILITIES OF CONIFEROUS FOREST UNDERSTORY STRATA CORRELATED WITH SUCCESSIONAL STAGES? FLAMMABILITY,SUCCESSION,SHRUB UNDERSTORY

831. 15 323 CAN WE DEVELOP CLASSIFICATION OF CONIFEROUS FOREST SPECIES BASED ON ABILITY TO SURVIVE FIRES OF DIFFERENT INTENSITIES? HEAT EFFECTS,ORGANISM,FIRE EFFECTS,MORTALITY

832. 15 323 CAN WE DEVELOP KEYS FOR THE IDENTIFICATION OF HABITAT TYPES (SENSU DAUBENMIRE) USING BOTANICAL ATTRIBUTES OF SUCCESSIONAL COMMUNITIES THAT DEVELOP AFTER FIRE? SUCCESSION,COMMUNITY

833. 15 323 DOES FIRE UPSLOPE INCREASE THE AVAILABLE NUTRIENT BUDGET OF DOWNSLOPE CONIFEROUS FORESTS TO ANY DEGREE, AND HOW FAR FROM THE FIRE MARGIN DOES THIS ENHANCEMENT OCCUR? NUTRIENTS,SOIL-WATER RELATIONS,TOPOGRAPHY

834. 15 323 WHAT ARE THE POSSIBLE STRATEGIES FOR USE OF FIRE AS A VEGETATION MANAGEMENT TOOL IN NATIONAL PARKS AND WILDERNESS AREAS? PRESCRIBED FIRE,GENERAL FIRE MANAGEMENT,RECREATION

835. 15 323 WHAT ARE THE RECOVERY RATES OF CONIFEROUS FOREST FLOOR BRYOPHYTE MICROCOMMUNITIES AFTER CROWN/GROUND FIRES? CUSHION PLANTS,GROUND FIRE,CROWN BURN,LITTER,DUFF

836. 15 324 WHAT ARE THE ACTUAL EFFECTS OF PRESCRIBED BURNING WHITE SPRUCE LOGGING SLASH IN THE SUB-ALPINE FOREST REGION ON REGENERATION OF WHITE SPRUCE? PRESCRIBED FIRE,FIRE EFFECTS,REPRODUCTION,,MOUNTAIN

837. 15 324 WHAT HAS BEEN THE ACTUAL HISTORIC ROLE OF FIRE IN NORTHERN CONIFEROUS FORESTS? WHAT ACTUAL EFFECTS HAS THE FIRE EXCLUSION POLICY BROUGHT ABOUT?--AND WHAT WILL THE LIKELY EFFECTS OF CONTINUED FIRE EXCLUSION BE? FIRE HISTORY,FIRE EXCLUSION

838. 15 327 WHAT ARE THE EFFECTS OF DIFFERING INTENSITIES OF FIRE ON THE DEVELOPMENT OR SUBSIDENCE OF PERMAFROST? PERMAFROST,FIRE EFFECTS,FIRE INTENSITY,SOIL-WATER RELATIONS,HEAT EFFECTS,ECOSYSTEM

839. 15 328 WHAT IS THE LONG-TERM EFFECT OF REPEATED SLASH-BURNING (OVER SEVERAL CUTTING CYCLES) ON THE PRODUCTIVITY OF CONIFEROUS FOREST ECOSYSTEMS, ESPECIALLY ON STEEP SLOPES IN AREAS OF HIGH RAINFALL? CLIMATE,PRESCRIBED FIRE,TIMING,PRODUCTIVITY,CONIFEROUS FOREST,ECOSYSTEM,MOUNTAIN,TOPOGRAPHY,SOIL,FIRE EFFECTS

840. 15 328 WHAT IS THE LONG-TERM EFFECT OF THE EXCLUSION OF FIRE FROM EXTENSIVE CONIFEROUS MONOCULTURES (PLANTATION) ON THE FUTURE PRODUCTIVITY OF THESE AREAS, IN TERMS OF BOTH PLANT AND ANIMAL POPULATION? FIRE EXCLUSION,CONIFEROUS FOREST,PRODUCTIVITY,ANIMALS

841. 15 342 HOW CAN WE PREDICT THE EFFECTS OF FIRES OF VARIOUS INTENSITIES ON PERMAFROST STABILITY AND DEPTH OF THAW AS MODIFIED BY LANDFORM, DRAINAGE, AND SOIL? PERMAFROST,FIRE EFFECTS,HEAT EFFECTS,SOIL-WATER RELATIONS,TOPOGRAPHY

842. 15 343 FIRE INTENSITY IS A FUNCTION OF AVAILABLE FUEL. THE AVAILABLE FUEL IS IN TURN A FUNCTION OF THE CURRENT MOISTURE REGIME. WHICH FIRE INTENSITIES BEST LEND THEMSELVES TO HEALTHY DYNAMIC, HETEROGENOUS ECOSYSTEMS? FIRE INTENSITY,DENSITY,COMPETITION,FLAMMABILITY,ECOSYSTEM

843. 15 343 HOW DOES THE ENERGY BUDGET OF A FOREST FIRE COMPARE WITH OTHER ENERGY EXCHANGE SYSTEMS? (BOTH BIOLOGICAL, E.G. PHOTOSYNTHESIS AND PHYSICAL E.G. AVALANCHE,FLOODING, EROSION,ETC.) FIRE INTENSITY

844. 15 343 WHAT ARE THE EFFECTS OF FIRE EXCLUSION ON THE DIVERSITY OF PLANT-ANIMAL COMMUNITIES? DOES IT LEAD TO

STABLE ECOSYSTEMS? DOES IT LEAD TO STERILE ECOSYSTEMS? WHICH SPECIES (PLANT, AVIFAUNA,FAUNA) ARE THE FIRST TO EXPERIENCE THE IMPACT OF FIRE EXCLUSION? COMMUNITY,FIRE EXCLUSION,VEGETATION,WILDLIFE

845. 15 345 DOES THE BENEFIT ACCRUED FROM EXCLUDING FIRE FROM THE FOREST EXCEED THE COST OF THIS EXCLUSION POLICY? THE BENEFITS UNDER CONSIDERATION ARE THOSE VALUES THAT MAN PLACES ON THE FOREST. FIRE EXCLUSION,ECONOMIC EFFECTS,HUMAN ECOLOGY

846. 15 346 IN THE DISCONTINUOUS PERMAFROST ZONE, WHAT ARE THE RELATIVE SUSCEPTIBILITIES OF VARIOUS LANDSCAPE UNITS AND VARIOUS VEGETATION TYPES TO FIRE-GENERATED FLOWSLIDES? FIRE EFFECTS,SOIL EROSION,PERMAFROST,COMMUNITY

847. 15 346 IT IS NOW COMMON PRACTICE IN ALBERTA AFTER PIPELINE OIL SPILLS TO BULLDOZE THE SURFACE (OIL-SATURATED) MATERIAL INTO PILES AND TO BURN THEM (OR ELSE TO ATTEMPT SURFACE BURNING OF OIL IN THE SPILL AREA WITHOUT BULLDOZING). WHEN THIS OCCURS IN FORESTED OR FOREST-MUSKEG AREAS, WHAT ARE THE SUCCESIONAL OPPORTUNITIES FOR EITHER ASSISTED OR NATURAL REVEGETATION ON THE BURNED OIL-SPILL AREAS? HUMAN DISTURBANCE,SUCCESSION,REPRODUCTION,PRESCRIBED FIRE,SOIL,MAN-CAUSED FIRE,SOIL STRUCTURE,SOIL-WATER RELATIONS

848. 15 347 THE CURRENT PHILOSOPHIES RELATING TO THE ROLE OF FIRE IN CONIFEROUS FORESTS ARE BASED ON: A) AN INCOMPLETE DESCRIPTION OF THE EARLIER HISTORY OF FIRE INCIDENCE, SIZE, INCIPIENT BEHAVIOR AND INTENSITY, B) AN INADEQUATE INVENTORY OF THE DYNAMIC FUEL COMPLEX EXISTING TODAY, AND C) A NON-OBJECTIVE ASSESSMENT OF THE IMPACT OF SUPPRESSION TECHNIQUES AND POLICIES. CAN WE BASE CRITICAL FUTURE FIRE MANAGEMENT DESIGNS ON REVIEWS OF PAST WORK WITH THE ABOVE LIMITATIONS? VALUE JUDGEMENT,HUMAN ECOLOGY

849. 15 348 DO SCORCHED AND BURNED TREES LEFT STANDING (AS OPPOSED TO BARE SNAGS) AFFECT THE RATE OR SUCCESS OF REGENERATION? FIRE EFFECTS,MORTALITY,HEAT EFFECTS,SMOKE EFFECTS,REPRODUCTION,CROWN BURN

850. 15 348 IF CONTROLLED BURNING IS TO BE CARRIED OUT, IS THERE ANY WAY TO ESTIMATE THE HEAT THAT THE SOIL WILL STAND TO JUDGE FOR REGENERATION AT A FUTURE DATE? HEAT EFFECTS,PRESCRIBED FIRE,SOIL,REPRODUCTION,FIRE EFFECTS

851. 15 348 IN AN OLD FIR STAND THE HEAT WILL BURST THE CONES TO RELEASE SEEDS FOR REGENERATION. HOW MUCH HEAT WILL THE SEED STAND BEFORE IT IS DESTROYED? SEED,HEAT EFFECTS,REPRODUCTION

852. 15 348 IN AREAS WHERE FIRE DESTROYS STANDING TREES BORDERING AREAS OF NATURAL OR MANIPULATED MEADOW (PARTICULARLY ALPINE AND SUB-ALPINE MEADOW), WHAT FACTORS DETERMINE THE RELATIVE EXTENT OF RE-FORESTATION?

CAN WE PREDICT THE POST-FIRE MEADOW EXTENT, DEGREE OF FOREST ENCROACHMENT? MOSAIC,ECOTONE,AREA SIZE,REPRODUCTION,FIRE EFFECTS,MOUNTAIN,COMPETITION

853. 15 348 IN SLASH BURNING, WHERE ONLY THE SMALLER COMPONENTS OF THE DEBRIS ARE CONSUMED, WHAT IS THE EFFECT ON THE LARGER COMPONENTS? FIRE EFFECTS,FUEL REDUCTION,PRESCRIBED FIRE,CHARCOAL,STEM

854. 15 348 IS FIRE EXCLUSION ENDANGERING THE DEVELOPMENT AND/OR MAINTENANCE OF UNGULATE RANGE(ELK,SHEEP) AND CONSEQUENTLY THE PRESENCE OF THESE ANIMALS? WILDLIFE,GAME ANIMAL,FIRE EXCLUSION,COMPETITION,HERBIVORY

855. 15 348 IS ONE CORRECT IN ASSUMING THAT LARGE STUMPS ARE MORE RESISTANT TO ROT FOR A NUMBER OF YEARS AFTER FIRE, AS THEY APPEAR TO BE? FIRE EFFECTS,DECOMPOSITION,STEM,ORGAN

856. 15 348 IS THERE A RELATIONSHIP BETWEEN ISOLATED PATCHES OF UNBURNED FOREST AND THE SOIL MOISTURE CONTENT AND HENCE VEGETATION TURGIDITY IN THOSE AREAS? FIRE EFFECTS,SOIL-WATER RELATIONS,FIRE BEHAVIOR,FIRE INTENSITY,MOSAIC

857. 15 348 WHAT IS THE RELATIONSHIP,IF ANY, BETWEEN SOIL DISTRIBUTION CHARACTERISTICS (INCLUDING SLOPE ASPECT, MORPHOLOGY, TEXTURE, MOISTURE, ETC.) AND THE RATE OF REGENERATION AFTER A BURN, AND THUS THE TOTAL AMOUNT OF ACCELERATION SOIL LOSS DUE TO EROSION? SOIL EROSION,SOIL STRUCTURE,SOIL,SOIL-WATER RELATIONS,TOPOGRAPHY,REPRODUCTION,FIRE EFFECTS

858. 15 350 HOW MUCH, FOR HOW LONG AND BY WHAT PROCESSES DO FIRES ALTER A) TOTAL WATER PRODUCTION, B) PEAK SNOWMELT RUNOFF, C) PEAK STREAM FLOWS, D) NUTRIENT LEVELS OF STREAMS, E) SEDIMENTATION AND F) EROSION FROM FORESTED WATERSHEDS? ECOSYSTEM,FIRE EFFECTS,STREAM,WATERSHED,NUTRIENTS,SOIL EROSION,CONIFEROUS FOREST

859. 15 350 WHAT ARE THE MICROMETEOROLOGICAL CHANGES IN RADIATION AND ADVECTION MICROCLIMATE AT EITHER SNOW OR SOIL SURFACE THAT RESULT FROM FIRES WHERE "NAKED" CANOPIES REMAIN COMPARED WITH TOTAL TIMBER HARVEST IN CLEAR CUTTING? MICROCLIMATE,SNOW,FIRE EFFECTS,SOIL,CROWN BURN,MANIPULATION COMPARISON

860. 15 350 WHAT IS THE RELATIVE DAMAGE CAUSED BY FIRE FIGHTING ACTIVITIES - SUCH AS LINE CLEARING AND "ROAD" BUILDING - ON EROSION AND SEDIMENTATION AS COMPARED TO THE DAMAGE CAUSED BY THE FIRE WITHOUT SUCH ACTIVITIES? HUMAN DISTURBANCE,SOIL EROSION,FIRE EFFECTS,FIRE EXCLUSION,MANIPULATION COMPARISON

861. 15 357 HOW CAN CONTROLLED FIRE MANIPULATION MAINTAIN ROUGH FESCUE (FESTUCA SCABRELLA) PRAIRIE ALONG THE SOUTHERN FRINGE OF THE BOREAL FOREST AREAS IN CANADA'S

WESTERN NATIONAL PARKS? GRASSLAND,CONIFEROUS FOREST,COMMUNITY,FIRE EFFECTS,PRESCRIBED FIRE,COMPETITION,WILDLIFE,PRODUCTIVITY

862. 15 357 HOW DOES ASPEN SUPPRESSION THROUGH CONTROLLED BURNING, EFFECT INVERTEBRATE AND VERTEBRATE POPULATIONS? DECIDUOUS FOREST,PRESCRIBED FIRE,ANIMALS,FIRE EFFECTS

863. 15 357 HOW DOES FIRE EXCLUSION IN CANADA'S WESTERN NATIONAL PARKS AFFECT PROCESSES WHICH WOULD HAVE TAKEN PLACE HAD MODERN MAN'S INFLUENCES BEEN LARGELY ABSENT? GENETIC RESPONSE,FIRE EXCLUSION

864. 15 364 HOW ARE THE NUTRITIONAL CHARACTERISTICS OF BROWSE SPECIES AFFECTED BY VARIOUS TYPES OF FIRES IN VARIOUS HABITAT TYPES - BOTH SHORT-TERM AND LONG-TERM? NUTRIENTS,SHRUB UNDERSTORY,WILDLIFE,GAME ANIMAL

865. 15 364 HOW DO PRESCRIBED FIRES COMPARE TO OTHER UNGULATE HABITAT MANIPULATION TECHNIQUES ON A COST-BENEFIT BASIS? WILDLIFE,GAME ANIMAL,PRESCRIBED FIRE,ECONOMIC EFFECTS,MANIPULATION COMPARISON

866. 15 364 WHAT ARE THE EFFECTS OF FIRE ON VARIOUS INTENSITIES, SIZES, TYPES, ETC., ON UNGULATE HABITAT, E.G. THE FIRE TYPES OR CHARACTERISTICS THAT PRODUCE THE BEST HABITAT, THE OPTIMUM FIRE SIZE IN VARIOUS HABITAT TYPES, THE HABITAT TYPES THAT PRODUCE THE BEST REGENERATION FOR UNGULATE USE? GAME ANIMAL,WILDLIFE,FIRE INTENSITY,FIRE DENSITY,ORGANISM

867. 15 365 WHAT ARE THE EFFECTS OF FOREST REMOVAL BY NATURAL OR ARTIFICIAL MEANS, ON A LARGE SCALE, ON THE WATER TABLE? SOIL-WATER RELATIONS,FIRE EFFECTS,HUMAN DISTURBANCE,ECOSYSTEM,CONIFEROUS FOREST

868. 15 365 WHAT ARE THE LONG AND SHORT TERM EFFECTS OF FIRE ON SOIL REACTION, ESSENTIAL MACRONUTRIENTS, ORGANIC CARBON CONTENT AND CATION EXCHANGE CAPACITY? NUTRIENTS,COMPOUNDS,SOIL,FIRE EFFECTS,TIMING

869. 15 365 WHAT ARE THE MERITS OF PRESCRIBED BURNING FOLLOWED BY SCARIFICATION AS A MEANS OF SEEDBED PREPARATION FOR REGENERATION BY DIRECT SEEDING OF SEVERAL CONIFEROUS SPECIES? PRESCRIBED FIRE,HUMAN DISTURBANCE,REPRODUCTION,CONIFEROUS FOREST,MANIPULATION COMPARISON

870. 15 365 WHAT EFFECT DOES FIRE HAVE ON THE VIABILITY OF CONIFEROUS SEEDS OCCURRING IN THE DUFF LAYER? DUFF,SEED,CONIFEROUS FOREST,FIRE EFFECTS

871. 15 365 WHAT IS THE DISTRIBUTION, AND FATE OF SEEDS FROM FIRE-INDUCED OPENING OF CONES? WHAT HAPPENS TO INDIVIDUAL CONIFEROUS SEEDS IN THE NATURAL HABITAT? CONIFEROUS FOREST,SEED,HEAT EFFECTS,FIRE EFFECTS,DISPERSION

872. 15 368 CAN WILDFIRES BE ALLOWED TO BURN THEMSELVES OUT IN WILDERNESS AND SEMI-WILDERNESS ZONES OF NATIONAL PARKS WITHOUT A MAJOR THREAT OF BURNING-OVER ADJACENT LANDS? WHAT ARE THE AVERAGE DISTANCES WHICH NATURAL FIRES TRAVEL UNDER VARIOUS PHYSIOGRAPHIC, CLIMATIC CONDITIONS? FIRE BEHAVIOR,VALUE JUDGEMENT,SOCIAL EFFECTS,ECONOMIC EFFECTS,GENERAL FIRE MANAGEMENT

873. 15 370 HOW IS INTENSITY OF FIRE RELATED TO LANDFORM IN VARIOUS PHYSIOGRAPHIC REGIONS? FIRE INTENSITY,TOPOGRAPHY

874. 15 370 HOW IS VEGETATION REGROWTH (COMPOSITION, DENSITY) RELATED TO FIRE INTENSITY? REPRODUCTION,FIRE INTENSITY,SPECIES DIVERSITY,FIRE EFFECTS,COMMUNITY

875. 15 370 WHAT BEHAVIORAL RESPONSES AND POPULATION CHANGES MIGHT BE OBSERVED IN BIRDS AND MAMMALS AS A RESULT OF FIRE? FIRE EFFECTS,EXPERIMENT ORIENTED QUESTION,BIRD,WILDLIFE,ANIMAL BEHAVIOR,POPULATION GROWTH,COMMUNITY

876. 15 370 WHAT MIGHT BE THE QUANTITY OF FORAGE (WOODY AND HERBACEOUS) YIELDED ON LAND BURNED AT DIFFERING INTENSITIES COMPARED TO YIELDS ON AREAS LOGGED AND SUBJECTED TO DIFFERING SITE PREPARATION TREATMENTS,(BOTH COMPARED TO UNDISTURBED CONTROL AREAS), FOR VARIOUS AGES FOLLOWING DISTURBANCE? HUMAN DISTURBANCE,MANIPULATION COMPARISON,EXPERIMENT ORIENTED QUESTION,PRODUCTIVITY,FIRE EFFECTS,FIRE INTENSITY

877. 15 770 HOW DOES A LARGE FOREST FIRE DIRECTLY AFFECT A MOUNTAIN STREAM IN TERMS OF ITS BIOTA? WOULD THE HEAT GENERATED BE SUFFICIENT TO KILL AQUATIC INVERTEBRATES, FISH, ETC.? STREAM,FISH,FIRE EFFECTS,HEAT EFFECTS

878. 15 770 WHAT ARE SOME LONG-TERM EFFECTS IN THE SOILS UNDERLYING AREAS OF REGULAR PRESCRIBED BURNING? CAN THE SOILS BE ADVERSELY AFFECTED IN THEIR CHEMICAL MAKE-UP? PRESCRIBED FIRE,SOIL,FIRE EFFECTS,FIRE FREQUENCY,NUTRIENTS

879. 15 773 HOW SHOULD CONTROLLED BURNING PLOTS BE ORIENTED AND WHAT SIZE AND SHAPE SHOULD THEY BE TO MAXIMIZE UNGULATE USAGE OF THE BURNT AREAS? AREA SIZE,PRESCRIBED FIRE,WILDLIFE,GAME ANIMAL

880. 15 773 WHAT EFFECT DOES FIRE HAVE ON NIVAL CONDITIONS DURING SUCCEEDING WINTERS, I.E. IS WINTER CARRYING CAPACITY FOR UNGULATES INCREASED OR IS NEW BROWSE UNAVAILABLE BECAUSE OF DRIFTING CONDITIONS, WIND CRUST, ICE LAYERS, ETC.? FIRE EFFECTS,WILDLIFE,SNOW,MICROCLIMATE

881. 15 774 I WOULD LIKE TO KNOW MORE ABOUT THE EFFECTS OF FIRE SUPPRESSION ON FOREST "INVASION" OF GRASSLAND ON BLACK SOILS IN THE FOOTHILLS AND PARKLAND AREAS. IS FOREST INVASION OF THESE "GRAZING AREAS" REALLY THE RESULT OF FIRE SUPPRESSION? FIRE EXCLUSION,SUCCESSION,DISPERSION,GRASSLAND,COMPETITION

882. 15 776 HOW MANY ACRES OF CONIFEROUS FOREST WILL NEVER YIELD A COMMERCIAL PRODUCT UNLESS THEY ARE THINNED OR BURNED AND THE REGENERATION THINNED? ECONOMIC EFFECTS,VALUE JUDGEMENT,COMPETITION,PRESCRIBED FIRE

883. 15 777 TO WHAT EXTENT WILL WILDLIFE SUCH AS MOOSE, ELK AND DEER UTILIZE THE CENTRE OF LARGE BURNED OVER AREAS? ANIMAL BEHAVIOR,GAME ANIMAL,AREA SIZE,FIRE EFFECTS

884. 15 777 UNDER WHAT CONDITIONS DO FIRES SKIP ABOUT LEAVING BLOCKS OF UNBURNED TIMBER? MOSAIC,ECOTONE,FIRE BEHAVIOR

885. 15 777 WHAT TYPES OF FIRES ARE WILD ANIMALS (OF WHAT SPECIES) UNABLE TO ESCAPE? DO FIRES REALLY KILL WILDLIFE? CROWN FIRES USUALLY OCCUR IN STANDS OF SPRUCE OR PINE, COVER TYPES NOT INTENSIVELY USED BY WILD UNGULATES. DO WILDFIRES REALLY ADVERSELY AFFECT WILDLIFE POPULATIONS IN A REGION? ANIMAL BEHAVIOR,FIRE EFFECTS,FIRE BEHAVIOR,MORTALITY,CROWN BURN,CONIFEROUS FOREST

886. 15 777 WHY IS FIRE SUPPRESSION NECESSARY ON TIMBER STANDS WHICH WILL NEVER BE MERCHANTABLE SUCH AS BLACK SPRUCE SWAMPS, TAMARACK BOGS, ETC., WHEN SUCH SUPPRESSION IS EXPENSIVE AND INHIBITS NATURAL DEVELOPMENT OF WILDLIFE HABITAT? ECONOMIC EFFECTS,FIRE EXCLUSION,VALUE JUDGEMENT,WILDLIFE

887. 15 778 WHAT EFFECTS MAY BE EXPECTED RELATED TO THE DISCHARGE REGIME OF STREAMS FROM FIRES LOCATED WITHIN THEIR DRAINAGE BASINS? WHAT CHANGES IN WATER QUALITY (E.G. STREAM TEMPERATURE, PH, DISSOLVED OXYGEN, SUSPENDED SOLIDS, NITRATE AND PHOSPHATE CONTENTS) OF STREAMS WOULD BE ASSOCIATED WITH FIRES ADJACENT TO THESE? FIRE EFFECTS,STREAM,PH,COMPOUNDS,NUTRIENTS,SOIL EROSION,MICROCLIMATE

888. 15 779 IN N.E. ALBERTA THERE ARE APPROXIMATELY 12,000 SQ MI. OF HABITAT IN WHICH RESIDENT BANDS OF WOODLAND CARIBOU EXIST. THIS AREA CONSISTS MAINLY OF WHITE SPRUCE STANDS INTERSPERSED WITH EXTENSIVE AREAS OF SPARSE TO DENSE BLACK SPRUCE MUSKEG. THE REGION RECEIVES EXTENSIVE FIRE PROTECTION ALTHOUGH FIRES OF VARYING INTENSITY DO OCCUR PERIODICALLY. THE EFFECT OF FIRE ON PRODUCTIVITY IN THIS TYPE OF HABITAT IS LARGELY UNKNOWN. IT IS CONCEIVABLE THAT A SPHAGNUM BOG COULD UNDERGO EXTENSIVE LONG-LASTING DAMAGE FROM FIRE. THIS WOULD IN TURN AFFECT DISTRIBUTION AND ABUNDANCE OF CARIBOU ON A LOCAL BASIS. IT IS ALSO CONCEIVABLE AND HAS BEEN DEMONSTRATED THAT FIRE ON UPLANDS CAN SET BACK SUCCESSION TO A STAGE FAVORABLE TO MOOSE. FIRE EFFECTS,WILDLIFE,GAME ANIMAL,CONIFEROUS FOREST,SOIL-WATER RELATIONS,SUCCESSION,PRODUCTIVITY

889. 15 802 IS FIRE A SIGNIFICANT FACTOR IN THE NATURAL SUCCESSION OF TREE SPECIES IN THE BOREAL FOREST AND HOW DOES THIS AFFECT THE REGENERATION OF ALL AREAS TO CONIFERS PARTICULARTLY WHITE SPRUCE? SUCCESSION,CONIFEROUS FOREST,FIRE EFFECTS,REPRODUCTION

890. 15 802 WHAT ARE THE EFFECTS OF REPEATED (AS FREQUENTLY AS EVERY 5 YEARS) SPRING WILDFIRES ON SOIL PRODUCTIVITY OF THE GREY WOODED SOILS OF ALBERTA? FIRE EFFECTS,SOIL,PRODUCTIVITY,FIRE FREQUENCY,TIMING

891. 15 803 IF A FIRE OCCURS IN A SUB-ALPINE FOREST WHERE SOILS ARE QUITE SHALLOW, SHOULD SALVAGE OF FIRE KILLED TIMBER BE UNDERTAKEN? I.E. ARE CHANCES OF HARMFUL EFFECTS FROM LOGGING IN A WATERSHED THAT MUCH GREATER THAT WE SHOULD NOT LOG AS OPPOSED TO A LOGGING OPERATION IN GREEN TIMBER IN THE SAME WATERSHED? HUMAN DISTURBANCE,MANIPULATION COMPARISON,SOIL STRUCTURE,MORTALITY

892. 15 803 WHEN TIMBER IS LEFT IN UPPER REACHES OF A WATERSHED FOR PROTECTION PURPOSES AND WHEN LOWER PORTIONS ARE LOGGED, SHOULD THESE PROTECTION FORESTS BE DELIBERATELY BURNED ONCE A VIGOROUS FOREST COVER HAS BEEN ESTABLISHED ON THE CUT-OVER AREA? I.E. COULD THE OVERMATURE PROTECTION FOREST BECOME AN EPICENTRE FOR INSECTS AND DISEASE SERIOUS ENOUGH TO AFFECT THE YOUNG ESTABLISHED FOREST GROWTH ON THE LOGGED AREAS OR WOULD THE HARMFUL EFFECTS TO THE WATERSHED (SNOW PACK, TIME OR RUN-OFF, ETC.) CREATED BY BURNING OUTWEIGH THE POSSIBLE DAMAGE TO THE YOUNG FOREST STANDS? HUMAN DISTURBANCE,FIRE EFFECTS,SOIL,SNOW,SOIL-WATER RELATIONS,INSECT,DISEASE,PRESCRIBED FIRE,FUEL REDUCTION,MANIPULATION COMPARISON,AGE

893. 15 804 IN AN OLD GROWTH SPRUCE-BALSAM STAND THAT IS CONTINUALLY PROTECTED FROM FIRE AND LOGGING, WHAT SORT OF WATER YIELD MAY BE EXPECTED AS THE STAND BECOMES MORE AND MORE DECADENT? IN A MONTANE FOREST, I.E. DOUGLAS-FIR/LODGEPOLE PINE, WHAT RATE OF TREE INCURSION CAN BE EXPECTED ON GRASSLAND WHEN FIRE IS EXCLUDED AND ALSO WHAT EFFECT ON WATER YIELD DOES THIS HAVE? CONIFEROUS FOREST,FIRE EXCLUSION,WATERSHED,AGE,COMPETITION,GRASSLAND

894. 15 804 IS THERE ANY RELATIONSHIP BETWEEN SLOPE, SOIL TYPE AND BROADCAST BURNING IN RELATIONSHIP TO SOIL EROSION? TOPOGRAPHY,SOIL STRUCTURE,PRESCRIBED FIRE,SOIL EROSION,FIRE EFFECTS

895. 15 804 A LOT OF OUR STANDS HAVE A POST LOGGING RESIDUAL OF ADVANCED GROWTH BALSAM FIR AND SNAGS. WHAT SORT OF ECOLOGICAL SUCCESSION CAN WE EXPECT ON THESE AREAS IF THERE IS NO BROADCAST BURNING OR OTHER TREATMENT. IN RELATION TO THE ABOVE, WHAT EFFECT DOES THIS HAVE ON WATER YIELD IN ANY SPECIFIC WATERSHED? WHAT WOULD BE THE EFFECT IF WE BROADCAST BURNED THESE AREAS? SNAG,SUCCESSION,FIRE EXCLUSION,HUMAN DISTURBANCE,CONIFEROUS FOREST,PRESCRIBED FIRE,WATERSHED,SOIL-WATER RELATIONS

896. 15 804 WHAT EFFECTS DOES THE EXCLUSION OF FIRE HAVE ON THE NATURAL ECOLOGICAL SUCCESSION OF PINE PIONEERS TO THE SPRUCE-BALSAM CLIMAX? SUCCESSION,FIRE

EXCLUSION,CONIFEROUS FOREST

897. 15 807 PROTECTION OF MOST OF OUR FORESTED LANDS FROM FIRE IS NECESSARY. HOWEVER, THE DEGREE OF PROTECTION SHOULD BE CORRELATED WITH THE RELATIVE LAND USE VALUES THAT WILL BE AFFECTED EITHER POSITIVELY OR NEGATIVELY BY FIRE. I DO NOT AGREE WITH SPENDING MASSIVE AMOUNTS OF MONEY ON AREAS WHERE A FIRE MAY DO LITTLE OR NO DAMAGE, INDEED MAY HAVE A POSITIVE EFFECT ON THE SITE. ECONOMIC EFFECTS,FIRE EFFECTS,FIRE EXCLUSION,VALUE JUDGEMENT

898. 15 809 WHAT ARE THE LONG-TERM BIOLOGICAL EFFECTS OF SMOKE ON RESIDUAL TREES WITHIN A BURN AND IN SURROUNDING AREAS? SMOKE EFFECTS

899. 15 813 AT WHAT THRESHHOLD FREQUENCIES AND FIRE INTENSITIES WILL PRESCRIBED FIRE ELIMINATE RABBIT HABITAT IN AN ASPEN STAND? SMALL MAMMAL,WILDLIFE,ANIMAL BEHAVIOR,DECIDUOUS FOREST,PRESCRIBED FIRE,FIRE FREQUENCY,FIRE INTENSITY,FIRE EFFECTS

900. 15 813 HOW FAST DOES A FIRE SPREAD IN AN ASPEN STAND UNDER EXTREME, HIGH, MODERATE AND LOW HAZARDS? FIRE BEHAVIOR,DECIDUOUS FOREST,FLAMMABILITY

901. 15 813 HOW HOT DOES A FIRE HAVE TO BE BEFORE ASPEN SUCKERING IS ELIMINATED? ROOTS,FIRE INTENSITY,DECIDUOUS FOREST,HEAT EFFECTS

902. 15 813 HOW SOON FOLLOWING A FIRE WILL CONIFEROUS (PINE OR WHITE SPRUCE) SPECIES GERMINATE IN AN ASPEN STAND? (ASSUMING A SEED SOURCE IS NEAR BY). CONIFEROUS FOREST,DECIDUOUS FOREST,SEED,REPRODUCTION,FIRE EFFECTS

903. 17 352 IS FIRE EXCLUSION LIKELY TO RESULT IN SIGNIFICANTLY HIGHER FIRE FREQUENCIES, RATES OF SPREAD AND INTENSITITES IN CONIFEROUS FORESTS? IF SO, IN WHICH FOREST TYPES AND HOW MUCH? FIRE EXCLUSION,FIRE FREQUENCY,FIRE BEHAVIOR

904. 17 352 UNDER A POLICY OF FIRE EXCLUSION, WHAT IS LIKELY TO BE THE EFFECT OF FUTURE TRENDS IN FOREST UTILIZATION AS THEY RELATE TO FUEL MANAGEMENT (AMOUNT, CONTINUITY, FLAMMABILITY, ETC.) AND GENERAL FIRE-FIGHTING EFFORT REQUIRED TO KEEP COSTS AND DAMAGES TO AN ACCEPTABLE LEVEL? GENERAL FIRE MANAGEMENT

905. 17 352 WHAT EFFECT MIGHT FIRE EXCLUSION HAVE ON RATE OF VEGETATIVE PRODUCTION AND AN INCREASE IN THE EXTENT OF PERMAFROST CONDITIONS IN NORTHERN LATITUDES? FIRE EXCLUSION,VEGETATION,PRODUCTIVITY,PERMAFROST

906. 17 352 WHAT MIGHT BE THE EFFECT OF FIRE EXCLUSION ON THE RATE OF LITTER AND FUEL ACCUMULATION IN A CONIFEROUS FOREST TYPE, AND CONCURRENT AND SUBSEQUENT CHANGES IN FUEL MOISTURE STATUS AND FLAMMABILITY? FIRE EXCLUSION,LITTER,FUEL/BIOMASS ACCUMULATION,FLAMMABILITY,FIRE BEHAVIOR

907. 17 372 AFTER FIRES, MANY TALL SNAGS AND STUBS REMAIN, WHICH ARE OFTEN CUT DOWN AND LEFT TO ROT (MUCH LESS OFTEN "SALVAGED" AS MERCHANTABLE TIMBER). SUCH SNAGS, IF LEFT, MAY REPRESENT THE MOST ATTRACTIVE SITES FOR FEEDING AND NESTING OF HOLE-NESTING BIRDS AND MAMMALS (JUST AS OLD UTILITY POLES ARE MORE ATTRACTIVE THAN THE NEW ONES PUT UP IN THEIR PLACE). DO SUCH SNAGS REPRESENT A SIGNIFICANT FIRE HAZARD, BY ATTRACTING LIGHTNING OR WHATEVER, GENERALLY, OR ONLY ALONG RIDGES AND ON HILLS? AND DO THEY REPRESENT SIGNIFICANT FOCI FOR INSECT PESTS? IN FACT, IS THERE ADEQUATE JUSTIFICATION FOR CUTTING THEM, TO SET AGAINST THEIR VALUES TO WILDLIFE? SNAG,BIRD,LIGHTNING-CAUSED FIRE,INSECT

908. 17 372 FIRE IS NORMAL, AND VIRTUALLY INEVITABLE, IN MOST CONIFEROUS FORESTS. IN THE BOREAL FOREST PROPER, IT IS ALSO VIRTUALLY UNPREVENTABLE, OWING TO THE VAST AREAS INVOLVED. OVER LARGE AREAS IN ALBERTA AND WESTERN SASKATCHEWAN, SPRUCE AND/OR SPRUCE-FIR FORESTS ARE VIRTUALLY LACKING EXCEPT IN MUSKEG SITES, OWING TO REPEATED FIRES, AND SUCCESSIONAL FORESTS OF POPLARS, WITH OR WITHOUT SPRUCE UNDERSTORY, TAKE THEIR PLACE. DO WE NEED TO CONSIDER THIS A BAD THING? VALUE JUDGEMENT

909. 17 372 THE SOUTHERN BORDERS OF THE BOREAL FOREST, BOTH ALONG THE PRAIRIES AND ON THE INTER-MOUNTAIN PLATEAUS OF B.C., HAVE A PARKLAND PHYSIOGNOMY, WITH SCATTERED GROVES OF POPLARS AMID GRASSLAND. ARE THESE PARKLANDS A RESULT OF PRAIRIE FIRES BREAKING INTO THE CLOSED FOREST, OR ARE THEY MERELY ECOTONAL IN NATURE, CONDITIONED BY SOIL MOISTURE AND ALKALINITY? SUCCESSION,GRASSLAND,SOIL-WATER RELATIONS,EXPERIMENT ORIENTED QUESTION

910. 17 372 WHILE THE POPLAR FORESTS WITHIN THE BOREAL FOREST ARE LARGELY OR ENTIRELY FIRE SUCCESSION, IS THIS ALSO TRUE FOR JACK PINE AND LODGEPOLE PINE STANDS? OR ARE THESE MAINLY CONDITIONED BY SANDY SOILS? OR BOTH? OR NEITHER? SUCCESSION,SOIL

VOCABULARY

Aesthetics
Age
Air Pollution
Allelopathy
Animal Behavior
Animals
Aquatic
Area Size
Arthropods
Ash
Bird
Charcoal
Chemical Retardant Effects
Climate
Community
Competition
Compounds
Coniferous Forest
Continuum
Crown
Crown Burn
Cushion Plants
Deciduous Forest
Decomposition
Density
Disease
Dispersion
Domestic Livestock
Duff
Economic Effects
Ecosystem
Ecotone
Elements
Epiphyte
Experiment Oriented Question
Fern
Fire Behavior
Fire Density
Fire Effects
Fire Exclusion
Fire Frequency
Fire History
Fire Intensity
Fire Statistics
Fish
Flammability
Fuel Reduction
Fuel/Biomass Accumulation
Fungus
Game Animal
General Fire Management
Genetic Response
Grassland
Ground Fire
Growth
Heat Effects
Herbage Understory
Herbivory
Human Disturbance
Human Ecology
Hydrology
Insect
Lake
Lightning Effects
Lightning-Caused Fire
Litter
Man-Caused Fire
Manipulation Comparison
Microclimate
Microorganism
Model
Mortality
Mosaic
Mountain
Nutrients
Organ
Organism
Permafrost
Ph
Planting
Population
Population Growth
Predation
Prescribed Fire
Productivity
Public Reaction
Recreation
Reproduction
Rock
Roots
Savanna-Woodland
Seed
Shrub Understory
Shrubland
Size Class
Small Mammal
Smoke Effects
Snag
Snow
Social Effects
Soil
Soil Erosion
Soil Structure
Soil-Water Relations
Species Diversity
Stability
Stem
Stream
Succession
Taiga
Timing
Topography
Tundra
Value Judgement
Vegetation
Volcanic Fire
Watershed
Wildlife
Windthrow
Zonation

INDEX

AESTHETICS
    7, 99, 208, 213, 249, 252, 413, 414, 552, 556, 800, 826
AGE
    169, 171, 179, 276, 379, 380, 405, 488, 520, 576, 577, 799, 892, 893
AIR POLLUTION
    38, 101, 109, 153, 156, 208, 312, 414, 556, 591, 596, 599, 826
ALLELOPATHY
    52, 289, 748, 791
ANIMAL BEHAVIOR
    62, 126, 198, 501, 544, 732, 794, 875, 883, 885, 899
ANIMALS
    73, 75, 79, 83, 85, 86, 88, 134, 135, 269, 320, 404, 473, 495, 496, 681, 684, 774, 780, 815, 820, 840, 862
AQUATIC
    12, 135, 782
AREA SIZE
    49, 50, 72, 86, 116, 134, 135, 140, 145, 154, 164, 172, 179, 187, 192, 201, 202, 301, 313, 347, 348, 354, 371, 389, 414, 417, 427, 429, 440, 445, 460, 483, 489, 496, 548, 553, 554, 575, 581, 614, 616, 627, 658, 665, 682, 684, 694, 736, 769, 782, 801, 808, 812, 813, 852, 879, 883
ARTHROPODS
    21, 288, 582, 702
ASH
    27, 63, 159, 203, 212, 221, 231, 235, 304, 306, 339, 358, 361, 374, 450, 471, 515, 565, 592, 595, 596, 632, 671, 760, 773, 785, 787, 809, 828
BIRD
    5, 12, 48, 78, 135, 189, 198, 254, 255, 320, 326, 337, 411, 486, 551, 555, 557, 637, 657, 674, 724, 732, 736, 737, 875, 907
CHARCOAL
    14, 69, 203, 212, 339, 356, 361, 450, 592, 596, 668, 671, 678, 787, 853
CHEMICAL RETARDANT EFFECTS
    393, 443, 449, 488, 490, 517, 541, 542, 546, 554, 555, 590, 644, 664, 676, 677, 689, 713, 808, 842, 852, 854, 861, 881, 882, 893
COMPOUNDS
    147, 222, 347, 390, 393, 772, 791, 868, 887

CONIFEROUS FOREST
103, 113, 129, 130, 144, 152, 158, 203, 215,
216, 217, 220, 221, 225, 226, 331, 341, 343,
347, 348, 359, 362, 363, 390, 391, 392, 393,
420, 430, 433, 434, 435, 436, 438, 442, 443,
471, 485, 486, 518, 543, 546, 550, 555, 556,
595, 596, 601, 608, 613, 617, 631, 661, 664,
666, 669, 675, 676, 677, 679, 680, 685, 686,
688, 690, 691, 698, 707, 720, 771, 772, 779,
784, 789, 790, 792, 796, 798, 801, 803, 804,
839, 840, 858, 861, 867, 869, 870, 871, 885,
888, 889, 893, 895, 896, 902
CONTINUUM
41
CROWN
8, 17, 39, 338, 438, 557, 669, 699
CROWN BURN
1, 13, 15, 19, 25, 72, 77, 344, 364, 373, 389,
438, 446, 553, 627, 669, 688, 699, 769, 835,
849, 859, 885
CUSHION PLANTS
769, 835
DECIDUOUS FOREST
40, 127, 128, 443, 454, 460, 485, 486, 575, 576,
577, 608, 629, 645, 726, 779, 792, 803, 862,
899, 900, 901, 902
DECOMPOSITION
22, 114, 115, 155, 158, 169, 207, 209, 282, 308,
356, 380, 390, 398, 408, 417, 459, 467, 520,
537, 643, 702, 811, 855
DENSITY
25, 120, 169, 171, 175, 179, 264, 379, 380, 385,
453, 454, 534, 560, 576, 581, 588, 676, 842
DISEASE
36, 39, 48, 171, 174, 271, 276, 278, 290, 298,
324, 365, 370, 484, 538, 543, 596, 751, 752,
753, 754, 775, 816, 892
DISPERSION
1, 126, 185, 348, 354, 375, 660, 762, 801, 871,
881
DOMESTIC LIVESTOCK
333, 525
DUFF
107, 108, 110, 115, 205, 207, 211, 391, 437,
587, 673, 685, 747, 835, 870
ECONOMIC EFFECTS
48, 125, 136, 153, 154, 213, 227, 372, 415, 419,
462, 481, 551, 578, 616, 623, 641, 696, 761,
780, 800, 845, 865, 872, 882, 886, 897
ECOSYSTEM
11, 12, 13, 46, 55, 81, 89, 94, 116, 117, 118,
123, 149, 193, 205, 212, 218, 234, 352, 421,
473, 474, 551, 554, 555, 593, 626, 672, 681,
689, 829, 838, 839, 842, 858, 867
ECOTONE
33, 345, 348, 489, 571, 574, 658, 694, 852, 884
ELEMENTS
16, 347, 772, 791

EPIPHYTE
654, 740
EXPERIMENT ORIENTED QUESTION
2, 3, 4, 5, 8, 17, 27, 29, 32, 51, 53, 68, 69,
70, 88, 126, 158, 178, 203, 210, 254, 289, 292,
309, 382, 403, 407, 464, 469, 501, 513, 573,
589, 631, 635, 712, 717, 738, 750, 814, 824,
875, 876, 909
FERN
184
FIRE BEHAVIOR
9, 16, 21, 22, 43, 100, 154, 165, 175, 176, 239,
268, 287, 294, 314, 328, 335, 492, 493, 508,
514, 516, 548, 615, 631, 640, 642, 683, 688,
699, 712, 718, 765, 769, 788, 793, 856, 872,
884, 885, 900, 903, 906
FIRE DENSITY
68, 544, 866
FIRE EFFECTS
47, 82, 100, 101, 104, 106, 107, 108, 111, 113,
117, 119, 120, 121, 123, 125, 127, 132, 133,
136, 137, 138, 139, 140, 141, 142, 143, 144,
145, 147, 148, 149, 150, 151, 153, 157, 159,
184, 189, 190, 191, 192, 193, 194, 195, 197,
198, 200, 203, 204, 210, 212, 213, 214, 215,
216, 218, 222, 223, 224, 226, 228, 230, 325,
332, 333, 337, 339, 342, 343, 347, 348, 351,
352, 353, 359, 360, 363, 364, 365, 367, 369,
374, 391, 393, 395, 418, 420, 431, 434, 439,
441, 447, 449, 469, 470, 471, 472, 473, 474,
475, 476, 478, 482, 484, 486, 487, 542, 543,
547, 551, 552, 553, 554, 555, 557, 595, 596,
597, 613, 615, 623, 624, 626, 627, 628, 629,
631, 634, 658, 659, 662, 663, 665, 668, 671,
672, 674, 675, 677, 678, 686, 687, 690, 691,
692, 695, 697, 719, 720, 721, 722, 724, 726,
727, 728, 729, 730, 732, 733, 734, 770, 771,
772, 773, 785, 786, 787, 788, 789, 790, 791,
793, 794, 795, 796, 797, 798, 802, 804, 805,
828, 829, 831, 836, 838, 839, 841, 846, 849,
850, 852, 853, 855, 856, 857, 858, 859, 860,
861, 862, 867, 868, 870, 871, 874, 875, 876,
877, 878, 880, 883, 885, 887, 888, 889, 890,
892, 894, 897, 899, 902
FIRE EXCLUSION
12, 20, 23, 24, 36, 46, 52, 67, 94, 112, 118,
136, 152, 169, 173, 192, 201, 202, 208, 219,
252, 258, 263, 271, 275, 282, 287, 302, 308,
310, 322, 325, 342, 345, 354, 362, 366, 370,
380, 387, 393, 401, 423, 434, 435, 454, 462,
466, 474, 485, 486, 488, 492, 493, 508, 519,
535, 542, 542, 546, 547, 549, 550, 551, 554,
555, 575, 577, 593, 596, 598, 600, 615, 617,
623, 625, 626, 630, 634, 650, 667, 673, 675,
683, 684, 685, 687, 689, 693, 695, 696, 704,
707, 708, 709, 722, 723, 731, 734, 751, 769,
780, 792, 798, 800, 805, 828, 837, 840, 844,
845, 854, 860, 863, 881, 886, 893, 895, 896,
897, 903, 905, 906

FIRE FREQUENCY
9, 22, 42, 45, 49, 50, 69, 99, 130, 131, 160,
163, 172, 173, 182, 186, 187, 188, 191, 204,
217, 228, 230, 262, 276, 278, 280, 281, 290,
291, 296, 316, 318, 319, 336, 342, 345, 376,
382, 394, 402, 421, 429, 444, 453, 454, 492,
505, 506, 510, 511, 519, 525, 528, 531, 532,
536, 537, 538, 539, 540, 541, 564, 571, 573,
588, 601, 614, 616, 638, 647, 649, 659, 663,
664, 665, 679, 681, 704, 712, 740, 750, 753,
755, 756, 758, 766, 768, 777, 789, 796, 878,
890, 899, 903
FIRE HISTORY
70, 117, 188, 263, 323, 324, 474, 613, 802, 837
FIRE INTENSITY
29, 37, 39, 47, 49, 50, 60, 64, 65, 66, 67, 77,
79, 86, 90, 102, 106, 120, 121, 132, 138, 142,
143, 147, 148, 159, 168, 172, 174, 185, 189,
217, 229, 234, 242, 283, 288, 305, 307, 310,
311, 316, 317, 318, 328, 343, 345, 349, 354,
363, 364, 369, 371, 376, 389, 391, 394, 395,
402, 408, 410, 416, 418, 421, 429, 437, 438,
439, 440, 441, 442, 448, 454, 457, 490, 493,
507, 521, 522, 529, 548, 564, 565, 587, 589,
602, 606, 611, 619, 620, 622, 631, 638, 639,
643, 645, 646, 649, 654, 655, 669, 670, 678,
682, 687, 698, 715, 740, 741, 755, 758, 760,
762, 763, 764, 771, 776, 782, 783, 784, 788,
801, 811, 838, 842, 843, 856, 866, 873, 874,
876, 899, 901
FIRE STATISTICS
68
FISH
18, 81, 89, 91, 92, 199, 218, 235, 304, 322,
339, 351, 353, 473, 478, 487, 628, 632, 668,
809, 829, 877
FLAMMABILITY
41, 44, 45, 128, 171, 268, 313, 336, 368, 372,
426, 601, 630, 678, 699, 727, 779, 798, 799,
830, 842, 900, 906
FUEL REDUCTION
50, 55, 74, 75, 76, 78, 83, 102, 103, 105, 110,
111, 115, 116, 124, 153, 154, 155, 156, 159,
161, 165, 166, 167, 168, 177, 203, 205, 206,
212, 220, 221, 222, 232, 236, 241, 259, 259,
261, 272, 272, 275, 279, 284, 291, 327, 329,
330, 330, 335, 356, 368, 381, 382, 383, 390,
392, 404, 413, 414, 415, 417, 418, 419, 421,
422, 426, 428, 429, 430, 432, 436, 439, 442,
448, 450, 470, 492, 493, 516, 524, 529, 559,
567, 568, 587, 599, 605, 622, 630, 640, 651,
661, 691, 697, 727, 742, 758, 759, 766, 767,
768, 775, 778, 804, 807, 809, 810, 811, 817,
823, 825, 826, 853, 892

FUEL/BIOMASS ACCUMULATION
9, 20, 22, 24, 79, 95, 98, 103, 114, 165, 169,
171, 173, 176, 177, 185, 187, 209, 214, 263,
267, 271, 273, 274, 276, 282, 287, 291, 302,
308, 315, 354, 357, 362, 379, 380, 382, 387,
394, 404, 421, 433, 438, 440, 453, 459, 468,
485, 489, 492, 493, 503, 504, 508, 513, 514,
519, 545, 562, 573, 578, 579, 615, 617, 622,
636, 642, 661, 673, 682, 683, 688, 693, 727,
742, 763, 764, 817, 906
FUNGUS
35, 232, 244, 265, 283, 408, 569, 754
GAME ANIMAL
6, 72, 98, 126, 137, 183, 185, 190, 197, 246,
257, 258, 301, 333, 354, 375, 403, 411, 436,
454, 460, 461, 463, 475, 482, 483, 485, 519,
547, 549, 581, 586, 627, 665, 694, 722, 728,
735, 736, 738, 739, 740, 769, 783, 854, 864,
865, 866, 879, 883, 888
GENERAL FIRE MANAGEMENT
97, 112, 128, 156, 167, 170, 227, 249, 251, 273,
287, 293, 294, 349, 371, 372, 394, 427, 429,
445, 451, 452, 462, 475, 481, 526, 548, 551,
603, 625, 641, 667, 725, 731, 774, 834, 872,
904
GENETIC RESPONSE
42, 298, 299, 300, 319, 704, 723, 798, 863
GRASSLAND
33, 96, 139, 332, 333, 345, 354, 375, 378, 384,
474, 522, 535, 546, 554, 555, 677, 861, 881,
893, 909
GROUND FIRE
130, 266, 288, 373, 382, 395, 416, 421, 422,
441, 505, 528, 531, 532, 534, 535, 557, 576,
596, 621, 660, 662, 690, 708, 709, 784, 810,
814, 824, 835
GROWTH
542
HEAT EFFECTS
42, 47, 214, 215, 216, 229, 311, 346, 360, 365,
391, 392, 406, 408, 439, 441, 442, 472, 479,
527, 552, 557, 589, 595, 607, 645, 669, 686,
693, 697, 698, 726, 760, 831, 838, 841, 849,
850, 851, 871, 877, 901
HERBAGE UNDERSTORY
34, 77, 132, 246, 257, 260, 267, 333, 377, 392,
435, 449, 455, 518, 525, 588, 627, 685, 708,
784
HERBIVORY
6, 72, 247, 309, 333, 375, 436, 454, 456, 460,
461, 463, 494, 525, 600, 648, 783, 854
HUMAN DISTURBANCE
48, 120, 125, 136, 155, 157, 158, 206, 209, 211,
220, 222, 341, 350, 366, 371, 372, 373, 390,
393, 413, 417, 421, 426, 427, 430, 432, 438,
439, 445, 448, 450, 470, 472, 477, 593, 597,
629, 657, 667, 689, 731, 772, 789, 791, 800,
802, 847, 860, 867, 869, 876, 891, 892, 895

HUMAN ECOLOGY
423, 512, 552, 591, 598, 614, 616, 618, 623,
627, 630, 634, 722, 845, 848
HYDROLOGY
8, 25, 37, 49, 80, 82, 93, 94, 161, 164, 237,
272, 274, 295, 322, 385, 466, 491, 559, 570,
572, 624, 639, 725, 778, 782, 806, 813, 818,
820, 823
INSECT
4, 23, 36, 39, 48, 67, 71, 91, 92, 150, 171,
176, 177, 178, 179, 180, 192, 265, 276, 285,
286, 287, 290, 298, 304, 309, 353, 354, 355,
359, 363, 365, 370, 395, 411, 447, 485, 578,
580, 612, 625, 637, 650, 657, 690, 692, 707,
708, 709, 724, 751, 752, 775, 829, 892, 907
LAKE
18, 49, 50, 69, 94, 195, 199, 785, 786, 829
LIGHTNING EFFECTS
178, 656, 679, 680, 725
LIGHTNING-CAUSED FIRE
99, 131, 202, 313, 336, 424, 425, 557, 601, 647,
656, 672, 679, 729, 797, 907
LITTER
20, 24, 26, 95, 110, 115, 169, 177, 236, 271,
285, 288, 318, 330, 398, 400, 536, 537, 685,
709, 768, 835, 906
MAN-CAUSED FIRE
427, 598, 616, 618, 729, 797, 847
MANIPULATION COMPARISON
28, 29, 73, 83, 98, 99, 120, 146, 161, 167, 169,
171, 173, 206, 208, 211, 222, 227, 233, 237,
238, 264, 270, 274, 279, 325, 341, 350, 355,
356, 366, 367, 396, 397, 398, 399, 404, 419,
426, 430, 465, 470, 483, 490, 497, 518, 523,
533, 539, 554, 590, 591, 592, 597, 611, 619,
620, 627, 629, 636, 642, 647, 686, 689, 716,
744, 767, 770, 772, 811, 816, 823, 825, 859,
860, 865, 869, 876, 891, 892
MICROCLIMATE
13, 14, 15, 19, 54, 71, 81, 100, 137, 153, 205,
212, 361, 374, 398, 490, 524, 533, 556, 566,
592, 595, 596, 619, 624, 662, 671, 733, 744,
747, 786, 802, 805, 820, 821, 822, 823, 827,
859, 880, 887
MICROORGANISM
37, 169, 214, 218, 243, 283, 305, 318, 324, 327,
399, 408, 467, 529, 558, 651, 670, 702, 764,
795
MODEL
188, 193, 199, 414, 422, 431, 432
MORTALITY
15, 22, 52, 176, 236, 257, 286, 287, 301, 303,
332, 343, 346, 360, 365, 376, 380, 405, 416,
422, 439, 441, 455, 459, 527, 553, 602, 603,
607, 621, 645, 655, 666, 669, 686, 794, 824,
831, 849, 885, 891
MOSAIC
1, 15, 33, 72, 164, 219, 268, 274, 313, 325,
348, 412, 420, 496, 500, 544, 581, 761, 782,
802, 820, 852, 856, 884

MOUNTAIN
125, 190, 572, 574, 617, 624, 829, 836, 839, 852
NUTRIENTS
10, 18, 37, 47, 49, 50, 55, 56, 58, 59, 63, 65, 66, 77, 81, 84, 89, 111, 114, 115, 135, 143, 147, 148, 159, 169, 171, 172, 173, 195, 203, 206, 209, 211, 218, 222, 234, 235, 237, 242, 243, 247, 257, 272, 274, 279, 281, 283, 296, 305, 306, 307, 308, 312, 324, 327, 329, 347, 357, 364, 369, 397, 398, 399, 400, 401, 409, 410, 412, 428, 436, 450, 458, 469, 472, 479, 487, 493, 494, 499, 505, 517, 524, 532, 536, 558, 564, 565, 566, 568, 570, 583, 585, 593, 605, 609, 611, 633, 653, 663, 700, 701, 705, 735, 746, 756, 757, 760, 762, 763, 764, 766, 768, 776, 778, 781, 782, 792, 804, 811, 817, 828, 829, 833, 858, 864, 868, 878, 887
ORGAN
2, 3, 8, 17, 63, 141, 143, 215, 220, 343, 360, 391, 441, 442, 595, 619, 631, 669, 686, 704, 801, 855
ORGANISM
5, 14, 35, 207, 231, 346, 365, 525, 607, 831, 866
PERMAFROST
731, 805, 838, 841, 846, 905
PH
90, 210, 593, 887
PLANTING
84, 88, 113, 124, 211, 212, 221, 223, 224, 384, 430, 436, 446, 449, 469, 517, 595, 633, 818
POPULATION
6, 9, 18, 20, 21, 23, 24, 26, 39, 42, 62, 67, 71, 72, 74, 78, 79, 98, 127, 128, 158, 175, 179, 180, 203, 217, 236, 243, 244, 264, 286, 299, 351, 389, 411, 430, 454, 495, 542, 542, 547, 560, 600, 613, 659, 675, 690, 708, 709, 752, 775, 815
POPULATION GROWTH
122, 187, 200, 549, 581, 612, 618, 663, 686, 690, 875
PREDATION
71, 75, 501, 708
PRESCRIBED FIRE
80, 81, 105, 110, 111, 112, 115, 116, 117, 124, 129, 130, 131, 132, 133, 134, 135, 138, 153, 153, 154, 156, 157, 159, 160, 161, 163, 180, 203, 204, 205, 208, 210, 212, 219, 220, 225, 226, 233, 257, 261, 272, 284, 302, 331, 333, 335, 337, 340, 341, 343, 349, 350, 355, 359, 363, 364, 366, 368, 375, 376, 378, 379, 381, 383, 392, 393, 394, 396, 403, 415, 421, 422, 428, 429, 430, 439, 440, 443, 444, 447, 489, 498, 505, 519, 529, 530, 542, 542, 548, 551, 555, 580, 591, 593, 599, 604, 624, 630, 652, 653, 659, 660, 661, 664, 665, 669, 672, 672, 674, 676, 677, 686, 690, 691, 692, 693, 694, 721, 754, 766, 797, 804, 806, 811, 819, 820, 826, 834, 836, 839, 847, 850, 853, 861, 862, 865, 869, 878, 879, 882, 892, 894, 895, 899

PRODUCTIVITY
2, 3, 17, 24, 34, 46, 49, 90, 91, 93, 111, 111,
134, 140, 141, 143, 147, 152, 173, 203, 216,
245, 246, 252, 257, 258, 267, 271, 279, 280,
282, 308, 311, 324, 354, 378, 397, 400, 404,
420, 431, 436, 479, 498, 515, 528, 531, 536,
566, 584, 604, 624, 649, 652, 663, 671, 683,
691, 703, 710, 717, 755, 758, 766, 768, 810,
811, 814, 815, 829, 839, 840, 861, 876, 888,
890, 905
PUBLIC REACTION
112, 136, 156, 208, 213, 239, 248, 250, 253,
256, 334, 407, 413, 414, 556, 591, 599, 614,
696, 722, 826
RECREATION
94, 95, 112, 137, 562, 834
REPRODUCTION
14, 20, 22, 23, 26, 30, 31, 55, 62, 67, 73, 75,
76, 85, 100, 105, 107, 119, 122, 123, 124, 126,
127, 146, 147, 160, 185, 200, 203, 211, 214,
216, 220, 221, 224, 226, 231, 234, 238, 240,
244, 257, 264, 271, 275, 277, 303, 327, 330,
341, 344, 355, 364, 367, 374, 376, 380, 384,
386, 417, 418, 430, 437, 446, 448, 449, 450,
454, 454, 455, 457, 460, 463, 469, 490, 494,
501, 507, 518, 519, 523, 524, 525, 526, 530,
533, 540, 542, 569, 577, 592, 594, 596, 600,
610, 613, 619, 629, 632, 648, 660, 671, 677,
691, 715, 741, 744, 777, 783, 804, 811, 817,
823, 836, 847, 849, 850, 851, 852, 857, 869,
874, 889, 902
ROCK
242, 760
ROOTS
24, 35, 39, 174, 232, 244, 391, 406, 442, 455,
569, 602, 603, 607, 710, 754, 901
SAVANNA-WOODLAND
443
SEED
1, 20, 21, 31, 73, 76, 85, 146, 186, 211, 215,
220, 240, 264, 341, 374, 446, 494, 499, 521,
522, 540, 542, 589, 592, 594, 596, 603, 613,
619, 648, 660, 700, 714, 726, 748, 749, 777,
801, 851, 870, 871, 902
SHRUB UNDERSTORY
34, 129, 140, 141, 142, 143, 152, 200, 226, 260,
267, 296, 331, 392, 455, 498, 502, 518, 528,
588, 596, 627, 649, 661, 664, 707, 721, 741,
753, 784, 792, 830, 864
SHRUBLAND
20, 63, 137, 138, 141, 160, 161, 185, 187, 204,
228, 230, 233, 245, 246, 247, 252, 257, 277,
280, 295, 297, 303, 326, 384, 405, 412, 429,
436, 460, 463, 475, 510, 526, 555, 581, 604,
719, 721, 728
SIZE CLASS
75, 380, 405, 520, 527, 605, 655, 698
SMALL MAMMAL
20, 48, 62, 74, 76, 189, 236, 261, 264, 326,
411, 501, 534, 551, 555, 557, 612, 648, 659,
674, 722, 736, 737, 749, 899

SMOKE EFFECTS
2, 3, 4, 5, 101, 109, 156, 337, 338, 752, 762, 827, 849, 898
SNAG
13, 19, 25, 99, 123, 158, 197, 255, 361, 520, 601, 637, 647, 657, 679, 680, 681, 733, 895, 907
SNOW
25, 80, 82, 98, 361, 470, 572, 594, 671, 737, 859, 880, 892
SOCIAL EFFECTS
248, 250, 407, 561, 563, 872
SOIL
10, 16, 21, 35, 47, 77, 100, 106, 111, 114, 115, 157, 159, 161, 166, 172, 184, 209, 210, 214, 216, 222, 228, 229, 232, 240, 251, 272, 274, 283, 284, 288, 305, 307, 318, 358, 364, 369, 377, 391, 393, 431, 437, 442, 446, 448, 453, 469, 472, 479, 507, 529, 530, 554, 557, 567, 592, 595, 602, 605, 609, 624, 633, 651, 670, 673, 691, 693, 697, 700, 719, 757, 759, 771, 776, 778, 781, 795, 804, 811, 839, 847, 850, 857, 859, 868, 878, 890, 892, 910
SOIL EROSION
55, 65, 121, 135, 146, 162, 163, 167, 168, 181, 216, 218, 224, 233, 241, 259, 297, 340, 352, 367, 385, 391, 473, 477, 494, 523, 590, 606, 628, 706, 710, 711, 773, 800, 812, 818, 819, 820, 825, 846, 857, 858, 860, 887, 894
SOIL STRUCTURE
27, 57, 58, 61, 64, 163, 181, 211, 231, 606, 847, 857, 891, 894
SOIL-WATER RELATIONS
13, 24, 43, 60, 64, 66, 137, 181, 212, 327, 340, 347, 348, 350, 354, 358, 361, 374, 388, 396, 440, 470, 476, 493, 594, 635, 646, 666, 685, 703, 706, 715, 730, 731, 743, 745, 769, 772, 790, 805, 833, 838, 841, 847, 856, 857, 867, 888, 892, 895, 909
SPECIES DIVERSITY
118, 129, 132, 142, 169, 171, 182, 185, 219, 230, 261, 269, 311, 312, 378, 387, 399, 404, 420, 423, 488, 495, 496, 502, 582, 689, 708, 736, 792, 828, 874
STABILITY
628, 811
STEM
42, 257, 343, 360, 363, 365, 392, 395, 416, 439, 441, 484, 543, 595, 607, 631, 645, 652, 669, 686, 690, 754, 853, 855
STREAM
9, 80, 81, 82, 89, 90, 91, 92, 93, 104, 148, 150, 195, 199, 210, 218, 235, 259, 304, 321, 322, 339, 351, 352, 353, 412, 471, 473, 476, 477, 478, 479, 480, 487, 497, 547, 558, 582, 583, 584, 585, 628, 632, 668, 772, 773, 785, 786, 787, 809, 812, 819, 822, 858, 877, 887

SUCCESSION
1, 11, 12, 22, 33, 40, 44, 46, 65, 67, 77, 79, 85, 87, 94, 96, 98, 118, 132, 133, 134, 142, 144, 145, 149, 150, 172, 183, 191, 193, 202, 216, 217, 219, 225, 234, 260, 261, 262, 280, 295, 296, 302, 310, 320, 324, 342, 345, 354, 387, 397, 399, 402, 404, 405, 408, 409, 411, 420, 423, 434, 443, 460, 461, 463, 484, 485, 488, 502, 505, 509, 510, 518, 535, 541, 554, 575, 577, 604, 608, 644, 649, 682, 683, 684, 689, 713, 715, 720, 722, 734, 735, 753, 755, 756, 765, 770, 771, 788, 791, 800, 803, 808, 828, 830, 832, 847, 881, 888, 889, 895, 896, 909, 910
TAIGA
719, 722, 723, 728, 734, 805
TIMING
104, 115, 117, 119, 124, 130, 131, 132, 138, 157, 180, 191, 194, 204, 207, 212, 218, 223, 225, 234, 283, 293, 295, 302, 304, 309, 311, 321, 329, 337, 340, 363, 367, 377, 402, 403, 421, 428, 443, 444, 446, 449, 473, 482, 505, 519, 522, 526, 527, 541, 548, 556, 582, 583, 585, 604, 628, 633, 639, 660, 672, 687, 747, 771, 796, 807, 815, 839, 868, 899
TOPOGRAPHY
12, 77, 94, 121, 214, 329, 344, 389, 391, 412, 494, 524, 613, 820, 833, 839, 841, 857, 873, 894
TUNDRA
728, 730, 734
VALUE JUDGEMENT
104, 208, 213, 256, 556, 591, 598, 599, 623, 625, 626, 634, 681, 687, 695, 696, 826, 848, 872, 882, 886, 897, 908
VEGETATION
26, 92, 112, 161, 196, 202, 238, 244, 306, 321, 324, 330, 344, 345, 346, 399, 405, 409, 437, 457, 488, 495, 523, 524, 588, 603, 610, 611, 621, 644, 652, 684, 703, 763, 822, 844, 905
VOLCANIC FIRE
70
WATERSHED
49, 164, 218, 350, 497, 547, 550, 554, 639, 858, 893, 895
WILDLIFE
136, 137, 140, 145, 197, 202, 204, 219, 226, 331, 333, 399, 444, 475, 483, 544, 551, 554, 555, 627, 719, 721, 722, 728, 734, 794, 799, 828, 844, 854, 861, 864, 865, 866, 875, 879, 880, 886, 888, 899
WINDTHROW
197, 276, 290
ZONATION
274, 313, 412, 492, 571, 572, 574, 761, 765, 819

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Malcolm M. Furniss and William F. Barr

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USDA Forest Service
General Technical Report INT-19
May 1975

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(Published with the approval of the Director
of the Idaho Agricultural Experiment Station
as Research Paper No. 7466)

INTERMOUNTAIN FOREST & RANGE EXPERIMENT STATION
Forest Service
U.S. Department of Agriculture
Ogden, Utah 84401
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ACKNOWLEDGMENTS

Much of the information presented here was obtained from specialists, who provided valuable unpublished data and references. In particular, we thank F. W. Stehr, Michigan State University, who provided information on *Malacosoma* spp., and D. W. Davis, Utah State University, who provided the information on *Hemileuca*. We are also grateful to R. C. Bechtel, Nevada Department of Agriculture (collections of *Hemerocampa vetusta gulosa* (Boisduval) and references to *Apterona crenulella* (Bruand)); H. H. Keifer, California Department of Agriculture (identification of *Aceria kraftella* Keifer); J. A. Powell, University of California (information on *Ethmia discostrigella* (Chambers)); and D. J. Williams, British Museum (identification of *Lecanium cerasifex* Fitch). R. I. Sailer, R. W. Hodges, E. L. Todd, and D. M. Weisman of the USDA Insect Identification Branch provided valuable references and authoritative identification of other taxa. We appreciate the helpful reviews of the manuscript by R. L. Furniss, Portland, Oregon, and J. A. Schenk and A. R. Gittins, University of Idaho.

ABSTRACT

Information is presented on insects and mites associated with important shrubs native to the Pacific Northwest. Forty-three insect species or insect groups and one mite species are discussed with emphasis placed on their geographic range, hosts, type of damage, appearance and habits, life cycle, and natural control. The orders of insects and mites represented are Coleoptera (beetles), Diptera (flies), Hemiptera (true bugs), Hymenoptera (ants), Lepidoptera (moths and butterflies), Thysanoptera (thrips), and Acarina (mites). A host plant index to the following genera is provided: *Acer*, *Alnus*, *Amelanchier*, *Arctostaphylos*, *Artemisia*, *Atriplex*, *Betula*, *Ceanothus*, *Cercocarpus*, *Chrysothamnus*, *Populus*, *Prunus*, *Purshia tridentata*, *Quercus*, *Ribes*, *Rosa*, *Salix*, *Sambucus*, *Symphoricarpus*, *Ulmus*.

CONTENTS

Page

INTRODUCTION 1

IMPORTANT INSECTS 3

COLEOPTERA: Beetles 3
- Buprestidae: Flatheaded or Metallic Wood Borers 3
  - *Acmaeodera* spp. 3
  - *Agrilus* spp. 4
  - *Anthaxia* spp. 6
  - *Dicerca horni* Crotch and *D. pectorosa* LeConte 7

- Cerambycidae: Roundheaded Wood Borers or Longhorned Beetles 7
  - *Crossidius* spp. 7
  - *Desmocerus* spp. 9

- Chrysomelidae: Leaf Beetles 10
  - *Altica* spp. 10
  - *Disonycha* spp. 11
  - *Trirhabda* spp. 11

- Curculionidae: Snout Beetles or Weevils 13
  - *Rhynchites bicolor* (Fabricius). . 13
  - *Sternochetus lapathi* (Linnaeus) . 14

- Scolytidae: Bark Beetles 16
  - *Chaetophloeus heterodoxus* (Casey) (=*Renocis*) 16

Page

DIPTERA: Flies 18
  Cecidomyiidae: Gall Midges 18
    Mayetiola sp. (=*Phytophaga*) . . . 18

  Tephritidae: Fruit Flies 20
    Eutreta, *Procecidochares*, and *Aciurina* spp. 20

HEMIPTERA: True Bugs 22
  Pentatomidae: Stink Bugs 22
    Chlorachroa sayi (Stäl) 22

HOMOPTERA: Aphids, Leafhoppers, Planthoppers, Scale Insects, and Allies. . 24
  Coccidae: Soft Scales 24
    Lecanium cerasifex Fitch 24
  Diaspididae: Armored Scales 26
    Lepidosaphes ulmi (Linnaeus) . . . 26
  Ortheziidae: Ensign Scales 28
    Orthezia artemisiae Cockerell . . 28

HYMENOPTERA: Ants, Bees, Sawflies, Wasps, and Allies 28
  Formicidae: Ants 28
    Pogonomyrmex occidentalis (Cresson) and *P. owyheei* Cole. . 28

LEPIDOPTERA: Moths, Butterflies, Skippers. . 29
  Ethmiidae: Ethmiid Moths 29
    Ethmia discostrigella (Chambers) . 29

  Gelechiidae: Gelechiid Moths 30
    Aroga websteri Clarke 30
    Filatima sperryi Clarke 32
    Gelechia mandella Busck. 33

  Geometridae: Measuringworms or Loopers 34
    Anacamptodes clivinaria profanata (Barnes and McDunnough) 34

Page

Lasiocampidae: Tent Caterpillars 37
Malacosoma spp. 37

Lymantriidae: Tussock Moths 42
Hemerocampa vetusta gulosa (Boisduval) 42

Nymphalidae: Brushfooted Butterflies . . 45
Nymphalis antiopa Linnaeus 45
N. californica (Boisduval) 47

Psychidae: Bagworm Moths 50
Apterona crenulella (Bruand) form *helix* 50

Saturniidae: Giant Silkworm Moths . . . 52
Hemileuca spp. 52

Tortricidae: Leafroller Moths 54
Synnoma lynosyrana Walsingham . . . 54

THYSANOPTERA: Thrips 55
Thripidae: Common Thrips 55
Frankliniella occidentalis (Pergande) 55

IMPORTANT MITES 57

ACARINA: Mites and Ticks 57
Eriophyidae: Gall Mites 57
Aceria kraftella Keifer 57

HOST PLANT INDEX 59

INTRODUCTION

The shrubs considered here are primarily species native to the Pacific Northwest, although they may also grow elsewhere.[1] They are deciduous woody plants, generally less than 10 feet tall, but some species may reach the size of small trees. These shrubs are commonly associated with the forest, either along its margins, within burns, in the understory, or along watercourses. Some, such as *Artemisia* and *Chrysothamnus*, grow in semiarid areas. Shrubs are an important ecological element, especially as food and shelter for wildlife--many are called browse plants. Their early presence after fires aids in stabilizing the watershed and is important to the succession of vegetation and the restoration of site productivity. In spite of their value, shrubs have received less study than other plant groups,[2] and similarly, the insects that utilize them as hosts have not been studied extensively.

The insect species discussed are characteristically restricted to certain kinds of plants. Furthermore, only certain parts of the host plant are usually infested by a particular insect.

Defoliation is perhaps the most common and conspicuous type of damage. Less evident damage may occur to the stems and to the reproductive parts at all stages leading to seed formation. Although root damage is known to occur, little information about it has been gathered. Infestation of stem by certain insects such as the poplar-and-willow borer may actually stimulate sprouting by older (taller) willow plants thus increasing their availability to game animals; however, the long-term effects of such infestations have not been determined. More commonly, infestation reduces growth and vigor (e.g., gall midges) or kills the affected plant or some of its branches (e.g., flatheaded woodborers).

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[1] C. Leo Hitchcock, Arthur Cronquist, Marion Ownbey, and J. W. Thompson. Vascular plants of the Pacific Northwest. Univ. Wash. Publ. in Biology, Vol. 17. Part 2, Salicaceae to Saxifragaceae, 597 p. (1964); Part 3, Saxifragaceae to Ericaceae, 614 p. (1961); Part 4, Ericaceae through Campanulaceae, 510 p. (1959); Part 5, Compositae, 343 p. (1955). 1955-1964.

Doris W. Hayes and George A. Garrison. Key to important woody plants of eastern Oregon and Washington. U.S. Dep. Agric., Agric. Handb. 148, 227 p. 1960.

[2] Wildland shrubs--their biology and utilization. USDA For. Serv. Gen. Tech. Rep. INT-1, 494 p. 1972.

The possibility that insects such as juice-sucking bugs act as vectors of diseases of browse plants has received little study but merits consideration in baffling instances of stand decadence where evident causes are lacking. Insect through their specificity, also influence succession by affecting species composition. It is hoped that this specificity may be utilized to rid areas of less desirable shrubs in favor of others. Besides affecting plant hosts, some insects have a toxic or repellent effect on animals that ingest them. These include caterpillars with urticating hairs and stink bugs which secrete a noxious fluid.

To seek better understanding of the relationships between insects and native shrubs, we have conducted surveys and limited studies of the relevant species. These studies have been supplemented with information from other entomologists (See Acknowledgments) and from the literature. We have selected for inclusion here only those insects about which useful information is presently available. Some species that are undoubtedly important, such as the root-feeding Curculionidae and Scarabaeidae, and the leaf- and stem-feeding Cicadellidae, have thus been omitted. This publication is intended as an initial step toward a comprehensive guide for forest, range, and wildlife resource managers and researchers. Information for such a guide, however, will require greatly expanded research on both the plants and the insects infesting them.

The text is divided into two parts: (1) A discussion of insects in alphabetical order; and (2) a host index.

A standardized format includes scientific and common names; geographic range; hosts; description of damage; appearance and habits; life cycle; and natural control. We have omitted applied control recommendations; those that exist can be sought in the cited literature or, preferably, from a University, County extension agent, State forestry office, or from the forest pest control staff of a Forest Service regional office.

IMPORTANT INSECTS

COLEOPTERA: BEETLES

Buprestidae: Flatheaded or Metallic Wood Borers

***Acmaeodera* spp.**

RANGE. Widely distributed in the United States and southern Canada. A great majority of the species occurs in the southwestern desert areas and the chaparral belts of the Western States.

HOSTS. Many species of broadleaf trees and shrubs. Host specificity is common. Representative browseland hosts include species of *Ceanothus*, *Cercocarpus*, *Quercus*, *Arctostaphylos*, *Rosa*, and *Purshia tridentata* (Pursh) DC.

DAMAGE. Larvae bore in the wood of roots, stems, and branches of the hosts. Their activity is usually confined to dead or injured portions. No extensive killing of host plants has been reported.

APPEARANCE AND HABITS. No information on the eggs is available. Larvae are typical flatheaded borers. The first expanded body segment lacks rugosities but has a single median groove or line. Larvae are white or cream colored, somewhat chunky in appearance, and up to one-half inch long. The pupa is found in a cell at the ending of a larval boring tunnel near the bark surface. Adults are somewhat triangular or cylindrical in shape and frequently have characteristic colorful markings. Adults of most species can be found on the host plant where they feed on tender leaves or flower parts, but they also commonly occur on nonhost flowers where they feed on pollen and mate.

LIFE CYCLE. The cycle is generally regarded to take 2 years. The adult stage is seasonally specific. Larvae generally overwinter.

References

Barr, William F. 1971. Family Buprestidae. P. 83-86, i
Hatch, Melville H. The beetles of the Pacific Northwest. Part V. Univ. Wash. Publ. Biol., Vol. 16.

Burke, H. E. 1917. Flatheaded borers affecting forest tre
in the United States. U.S. Dep. Agric. Bull. 437, 8

Fall, H. C. 1899. A synopsis of the species of the genus
Acmaeodera of America north of Mexico. J. N.Y. Entomol. Soc. 7:1-37.

***Agrilus* spp.**

RANGE. Widely distributed in the United States and southern Canada. A large number of species have been described. Species are not as well represented in the brow
plant areas of the Western United States and Canada as in other areas, however.

HOSTS. Many broadleaf trees and shrubs; some species are host specific. Browse plants frequently attacked inclu
species of *Chrysothamnus*, *Arctostaphylos*, *Salix*, *Betula*, *A*
and *Quercus*.

DAMAGE. Damage to the host plant is usually negligib
but larvae can girdle and kill individual branches and twi
(fig. 1).

APPEARANCE AND HABITS. The flattened or scalelike eggs are deposited on bark of the host plant singly or in small clusters, and are usually covered with a protective, varnishlike secretion. They are difficult to find. The larva is elongate and up to 25 mm long. Only the first bo
segment is expanded; it bears a median groove. The last b
segment terminates in a pair of conspicuous chitinized spi
The mature larvae usually mine the inner bark and wood and may produce a spiraled boring around twigs, branches, and trunks of living or dead trees and shrubs. Occasionally, they may bore exclusively in the wood of stems and roots o
shrubs. The pupa is about half the length of the mature l
it is creamy white and characteristically slender. Pupati
takes place in the cell constructed by the larva in the wo
Adults are slender and cylindrical. They are blue to copp
iridescent, and frequently have pubescent spots or stripes
They are usually found on the host plant, where they may f

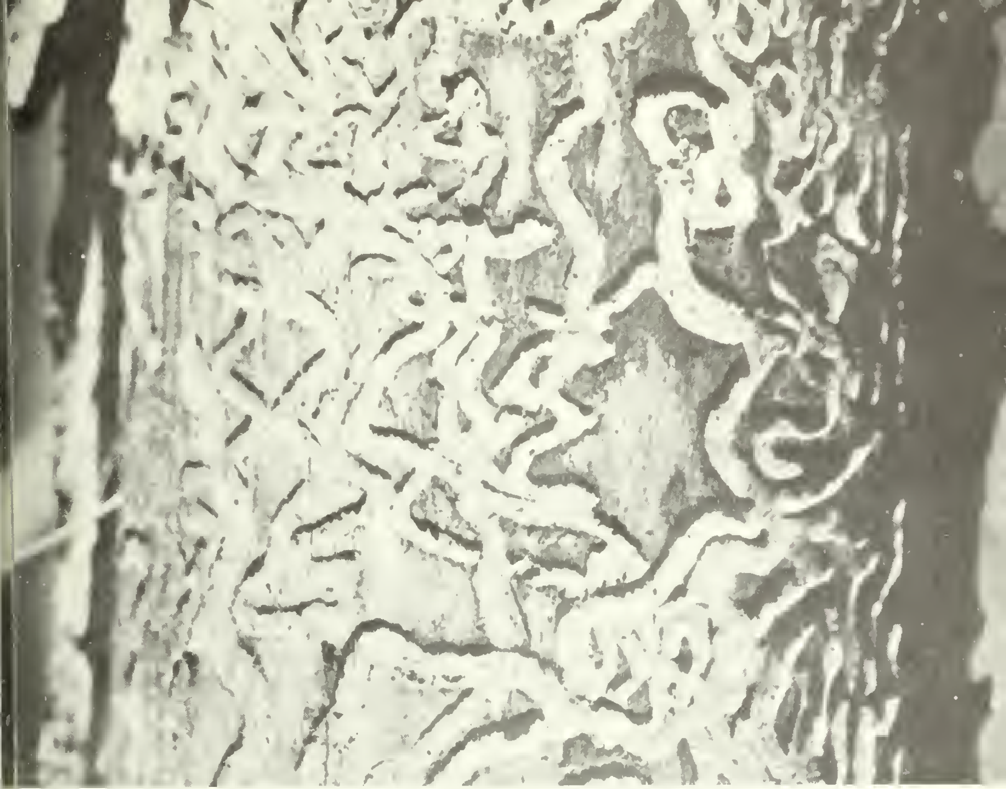


Figure 1.--Larval mines of Agrilus politus *(Say) on Scouler willow.*

on tender bark or leaves. Some species feed on fungus spores and some frequent flowers where they feed on pollen.

LIFE CYCLE. The cycle takes 1 or 2 years, depending on the species. Larvae normally constitute the overwintering stage. Pupation usually occurs in the spring to early summer and lasts for approximately 2 weeks.

NATURAL CONTROL. Hymenopterous parasites appear to be an important regulating factor in populations of *Agrilus* spp. Parasitism accounting for losses of up to 50 percent of the population has been reported for some species.

References

Barr, William F. 1971. Family Buprestidae. P. 87-89, in: Hatch, Melville H. The beetles of the Pacific Northwest. Part V. Univ. Wash. Publ. Biol., Vol. 16.

Burke, H. E. 1917. Flatheaded borers affecting forest trees in the United States. U.S. Dep. Agric. Bull. 437, 8 p.

Fisher, W. S. 1928. A revision of the North American specie
of Buprestid beetles belonging to the genus *Agrilus*.
U.S. Nat. Mus. Bull. 145, 347 p.

Anthaxia **spp.**

RANGE. Throughout the Western United States and Canada.

HOSTS. Many plants, including species of *Cercocarpus*, *Rosa*, *Amelanchier*, *Quercus*, *Prunus*, *Salix*, *Ceanothus*, and *Purshia tridentata* (Pursh) DC.

DAMAGE. Branches and small twigs of host plants are frequently killed or damaged by the boring and girdling of the larvae. Host plants thus affected are unsightly and may attract other boring insects. The many species of *Anthaxia* are believed to be much more highly host specific than has been reported.

APPEARANCE AND HABITS. Eggs are not known. The larvae are small, cream-colored flatheaded borers. The first body segment is without distinct chitinous rugosities but has an inverted V on the dorsal surface and a median line on the ventral surface that does not reach the hind margin. The larvae are found beneath or in the bark of the host. Pupati
is believed to take place in a specially constructed cell in the wood. The adults are small, conspicuously flattened and broadened; they are dark bronze, blackish, or green, and have characteristic pronotal reticulations. Adults are foun
on the foliage or flowers of the host plant, on flowers of various species of Compositae, or commonly on *Eriogonum*.

LIFE CYCLE. The cycle is not known, but is believed to last 1 year. Adults are found from early spring to midsumme
depending on the species and locality.

References

Barr, William F. 1971. Family Buprestidae. P. 67-73, in: Hatch, Melville H. The beetles of the Pacific Northwest. Part V. Univ. Wash. Publ. Biol., Vol. 16.

Burke, H. E. 1917. Flatheaded borers affecting forest tree
in the United States. U.S. Dep. Agric. Bull. 437, 8 p.

Dicerca horni **Crotch and *D. pectorosa* LeConte**

RANGE. Throughout their host ranges in the Western United States and British Columbia.

HOSTS. Several browse shrubs. *D. horni* infests species of *Ceanothus*, *Cercocarpus*, and *Alnus*, whereas *D. pectorosa* infests species of *Prunus*.

DAMAGE. Larvae bore in dead wood of living trees and shrubs or in the wood of dead or dying trees and shrubs. They probably do not kill the plant by themselves.

APPEARANCE AND HABITS. The egg stage is not known. Larvae are typical large flatheaded borers. The first body segment lacks distinct chitinous rugosities but has an inverted V on the dorsal surface that is reticulated anteriorly and has a median line on the ventral surface that reaches the hind margin. Pupation is believed to occur in old larval galleries within the woody portions of the host plant. Adults are dark brown to coppery, 12 to 30 mm long, with a pair of longitudinal median ridges on the pronotum. *D. horni* usually has long fine hairs on the elytra. The front margin of the prosternum of *D. pectorosa* is broadly lobed laterally. The adults are found most often on the bark or foliage of the host plants. Their feeding habits are not known.

LIFE CYCLE. The details of the life cycle of these insects have not been recorded.

Reference

Barr, William F. 1971. Family Buprestidae. P. 67-73, in: Hatch, Melville H. The beetles of the Pacific Northwest. Part V. Univ. Wash. Publ. Biol., Vol. 16.

Cerambycidae: Roundheaded Wood Borers or Longhorned Beetles

Crossidius **spp: Desert shrub longhorned rootborers**

RANGE. Arid and semiarid areas of the western States and Canadian Provinces.

HOSTS. Principally *Chrysothamnus nauseosus* (Pall.) Britt., *C. viscidiflorus* (Hook.) Nutt., and *Artemisia tridentata* Nutt.

REPRESENTATIVE SPECIES. *C. hirtipes* LeConte, *C. punctatus* LeConte, *C. coralinus* (LeConte), and *C. ater* LeCont

DAMAGE. The larvae bore in the roots of the host plants When larvae are numerous or when successive generations infes individual plants, partial killing or general unthrifty condition may result.

APPEARANCE AND HABITS. Eggs are deposited singly on the bark of stems and branches just above the soil surface. The eggs are covered with a protective secretion and coated with soil particles which give the egg a scalelike appearance The larva is a typical roundheaded borer, white to cream-colored, legless, and up to 2-1/2 inches long. The boring activities of this developmental stage may riddle the root. As many as 10 to 12 larvae may occupy a single plant. The pupa is large and yellowish and found generally in the wood just below the bark surface in the crown or down to 6 inches beneath the soil surface. Pupation occurs in the old larval boring tunnel. Adults are cylindrical with long antennae; they have characteristic colors and markings consisting of a yellow-brown or red base color and usually with a broad black apical band or an irregular sutural stripe on the elytr The adults appear only during the late morning and early afte noon. They are found most commonly on the flowers of their host or related plants where they feed on pollen.

LIFE CYCLE. The cycle takes 2 years. Overwintering stages are the egg and medium-sized larva. Pupation generall occurs in late summer and lasts approximately 2 weeks. The adults are most evident during the early fall.

NATURAL CONTROL. The clerid beetles, *Enoclerus acerbus* (Wolcott) and *E. abruptus* (LeConte) have been reported as predators of the larvae.

References

Linsley, E. G., and J. A. Chemsak. 1961. A distributional and taxonomic study of the genus *Crossidius* (Coleoptera: Cerambycidae). Entomol. Soc. Am. Misc. Publ. 3:25-64.

Penrose, R. L. 1967. Bionomics of the species of Idaho *Crossidius* with taxonomy of immature stages. M.S. Thesis, Univ. Idaho, 69 p.

Penrose, Richard L. 1973. A biosystematic study of the genus *Crossidius* north of Mexico (Coleoptera: Cerambycidae). Ph.D. Thesis, Univ. Idaho, 397 p.

Desmocerus **spp.: Elderberry longhorned borers**

RANGE. All the western States and British Columbia.

HOSTS. Several species of *Sambucus*.

DAMAGE. Boring by the larvae may result in the weakening or killing of individual plant stems. Extensive plant mortality has not been reported.

APPEARANCE AND HABITS. The eggs are not known, but they are believed to be laid in crevices of the bark at the base of the plant. The larvae are typical roundheaded borers up to 3 inches long. They feed in the living roots and basal stems and may cause the formation of large galls up to 10 inches in diameter at the base of the stems. Before pupation, a larva will tunnel up into the base of a stem, construct a pupal chamber in the pith, and cut an exit hole to the bark which is then filled with frass. The cream-colored pupa has typically long antennae. Adults are large, attractively colored beetles; the elytra vary from uniform orange or red to greenish or blue-black with the lateral margins narrowly to broadly reddish. Sexual dimorphism occurs in several species. Specimens are most commonly encountered as they rest on the leaves of their host plant. Occasionally they can be found on flowers.

LIFE CYCLE. At least 2 years are required to complete a generation. Adults are active for a short time during the summer. Larvae of several different instars may overwinter. Pupation takes place as early as March and as late as June, depending upon the locality.

References

Craighead, F. C. 1923. North American Cerambycid larvae. Can. Dep. Agric. (N.S.) 27:86-88.

Webb, J. L. 1905. Description of a new species of *Desmocerus* with a synoptic table of the genus. Entomol. Soc. Wash. Proc. 7:104-105.

Chrysomelidae: Leaf Beetles

Altica spp: Leaf flea beetles

RANGE. Throughout the western States and Canadian Prov

REPRESENTATIVE SPECIES AND HOSTS. *A. bimarginata* Say, which infests *Salix*, and *A. ambiens* (LeConte), which infests *Alnus*.

DAMAGE. Defoliation by adults and larvae can be sever locally. Reports of plant damage are made regularly each year. Plant mortality is uncommon, however.

APPEARANCE AND HABITS. The eggs are elongate, approximately 1.5 mm long, and pale to deep orange. They are laid singly or in groups of 30 or more on the leaves, stems, and branches of host plants and occasionally on other plants nea The larvae are elongate and brown to black, with the head and thorax frequently shiny and the ventral surfaces yellowi Larvae skeletonize the leaves of host plants. The pupae ar orange to brownish in color and occur in the soil beneath th host plant. Adults are blue to metallic steel blue and 5 to mm long. They tend to jump when disturbed. They perforate leaves of the host plant when feeding.

LIFE CYCLE. One, two, and perhaps more than two generations a year are known to occur. The adults overwinter and oviposit in the late spring. Eggs hatch in 5 to 10 days. D ing on the species, larval development is short, varying fro 9 to 21 days, or is extended, ranging from 25 to 53 days. Pupation lasts from 6 to 10 days.

NATURAL CONTROL. Very few parasites or predators have been associated with these flea beetles. In Idaho, the principal population regulators are the predaceous bug *Sinea diadema* (Fabr.) and a predaceous beetle *Lebia* sp.

Reference

Barstow, D. A., and A. R. Gittins. 1971. Life history studies of a willow leaf beetle *Altica bimarginata* Say in north Idaho (Coleoptera: Chrysomelidae). Univ. Idah Agric. Exp. Stn. Res. Bull. 80, 20 p.

Disonycha spp: Five-striped flea beetles

RANGE. The more semiarid areas of western North America.

REPRESENTATIVE SPECIES AND HOSTS. A relatively large number of species is represented in the genus. *D. latiovittata* Hatch infests *Salix*, whereas *D. latifrons* Schaeffer infests *Chrysothamnus*.

DAMAGE Considerable defoliation of the host plants may occur locally but extensive damage or mortality has not been reported.

APPEARANCE AND HABITS. The eggs are yellowish and occur in groups on the host plant or in soil adjacent to the host plant. The larva is black with a distinct greenish or bluish luster. When mature it is approximately one-half inch long. Larvae usually occur in groups feeding on leaves on the host plant. Adults are ivory colored with narrow to broad black stripes on the elytra and discal markings on the thorax. The legs are red or orange. They occur on the host plant occasionally, along with the mature larvae. Pupation occurs in the soil.

LIFE CYCLE. Several generations a year may occur, depending upon the locality. The adult overwinters and lays eggs in the spring. Eggs hatch in 7 to 10 days. The larval stage lasts for up to 8 weeks and the pupal stage 3 to 6 weeks.

Reference

Blake, D. H. 1933. Revision of the beetles of the genus *Disonycha* occurring in America north of Mexico. U.S. Nat. Mus. Proc. 82:1-66.

Trirhabda spp.

RANGE. Throughout the United States and portions of Canada.

REPRESENTATIVE SPECIES AND HOSTS: *T. pilosa* Blake, which infests *Artemisia tridentata* Nutt., and *T. nitidicollis* LeConte and *T. lewisii* Crotch, which feed on *Chrysothamnus nauseosus* (Pall.) Britt. and *C. viscidiflorus* (Hook.) Nutt.

DAMAGE. Under local conditions, host plants may be severely defoliated. Outbreaks or localized plant mortality have been reported for *C. nauseosus* in New Mexico in 1957, and for *A. tridentata* in southeastern British Columbia in 1954 and 1961 and in southern Idaho in 1968.

APPEARANCE AND HABITS. The yellowish eggs are deposited singly or in clumps on the host or on litter around the base of the host. Larvae attain one-half inch in length. They are metallic blue or green, rather elongate, and relatively slow moving. They feed in groups on the upper portion of the host plant. Larvae of several different sizes may be present at a given time. The yellowish pupae occur in the soil to a depth of several inches around the base of the host. Usually they are found in sand or sandy loam soil. Adults vary in color from dull yellowish with greenish to black pronotal spots and elytral stripes to green or blue-green, with or without pale stripes on the elytra. They are usually foun feeding on the upper portion of the host plant.

LIFE CYCLE. There is one generation per year. In speci thus far investigated, the egg is the overwintering stage. T larvae occur from early spring to midsummer depending upon th locality. Pupation lasts up to 2 weeks. Adults begin emergence in the spring and are active for several months.

NATURAL CONTROL. The tachinid fly, *Aplomyiopsis xylota* (Curran) has caused 18 to 40 percent mortality in larvae of *Trirhabda lewisii*, *T. eriodictyonis*, *T. nitidicollis*, *T. pilosa*, and *T. manisi*. The most common predator is the penta tomid, *Perillus splendidus* (Uhler); the carabids, *Philophuga viridis amoena* LeConte and *Lebia cyanipennis* Dejean also prey on some species.

References

Blake, D. H. 1931. Revision of the beetles of the genus *Trirhabda* north of Mexico. U.S. Nat. News Proc. 79:1-36

Hogue, S. M. 1970. Biosystematics of the genus *Trirhabda* LeConte of America north of Mexico (Chrysomelidae: Coleoptera). Ph.D. Thesis, Univ. Idaho, 212 p.

Hogue, Steve M. 1971. *Trirhabda* LeC. P. 193-196, in: Hatch Melville H. The beetles of the Pacific Northwest. Part V. Univ. Wash. Publ. Biol., Vol. 16.

Massey, C. L., and A. A. Pierce. 1960. *Trirhabda nitidicollis* a pest of rabbitbrush in New Mexico. J. Range Manage. 13:216-217.

Pringle, W. L. 1960. The effect of a leaf feeding beetle on big sagebrush in British Columbia. J. Range Manage. 13:139-142.

Curculionidae: Snout Beetles or Weevils

Rhynchites bicolor **(Fabricius): Rose curculio**

RANGE. All the western States and Provinces of the United States and Canada.

HOST. Wild and cultivated *Rosa*.

DAMAGE. Niches are chewed in developing flower buds by adults while feeding and for ovipositing. Resulting flowers do not develop normally. Following oviposition, the female may puncture the flower stem, causing the bud to wilt and mummify.

APPEARANCE AND HABITS. Eggs are white, elliptical, about 1.2 by 1.1 mm, and are found in the developing flower buds. Each female lays approximately 40 eggs. The larvae are white, curved, legless, and about 7 mm long. They develop in mummified buds that have remained on the plant or dropped to the ground. Pupation takes place in an earthen cell in the soil. Pupae are white. Adults are robust, somewhat pear-shaped, with a prominent beak. The upper surface of adults is bright red and the ventral surface and appendages are usually black.

LIFE CYCLE. There is one generation per year. Mature larvae overwinter in the soil. Pupation occurs from mid-March to early May and lasts for about 9 days, but the adults do not emerge from the soil until 2 weeks later. Adults are active throughout much of the summer. Eggs hatch in 1 to 2 weeks and larval development is complete in 6 to 12 weeks.

NATURAL CONTROL. An ichneumonid wasp *Pemelucha* sp. has been reported to parasitize larvae.

References

Balduff, W. V. 1959. Obligatory and facultative insects in rose hips, their recognition and bionomics. P. 78-123, in: Ill. Biol. Monogr. 26.

Hoerner, J. L. 1936. Western rose curculio. Colo. Exp. Stn. Bull. 432, 19 p.

Sternochetus lapathi **(Linnaeus): Poplar-and-willow borer**

RANGE. Native to Europe and Asia. It was discovered in New York in 1882 and now occurs throughout southern Canada and the northern half of the United States.

HOSTS. Preferably *Salix*; much less commonly, *Populus* (but not *Populus tremuloides* Michx.); and rarely, *Alnus* and *Betula*.

DAMAGE. Stems are killed either by mining or by breakage of the weakened part. Infestations occur more commonly near the ground and in stems 1 to 3 inches in diameter. Presence of infestation is indicated by wood fragments expelled by larvae through holes bored in the stem. Infestations are very common and usually persist in the same stem or plant for several years.

APPEARANCE AND HABITS. The egg is white and measures 1.1 by 0.8 mm. Eggs are laid singly or in groups of two to four in holes chewed in the bark by the female beetle. The mature larva (fig. 2A) is about 1 cm long, white, legless, and C-shaped, with a shiny reddish-brown head. Young larvae overwinter between the bark and the wood. In spring, they mine partly around the stem, then upward in the wood or pith for a distance of approximately 5 cm. Before pupating, the larva orients itself headfirst toward the mine entrance. The adult (fig. 2B) is 7 to 10 mm long, dark brown to black, mottled with light brown and gray scales. The tips of the elyt sides of the thorax, and parts of the legs usually have a pinkish cast. The body surface is dull and rather rough in appearance. Adults are said to be active during evening and morning but become inactive in daytime when temperatures exceed 26° C. They do not take to flight readily and if disturbed, will feign death by dropping to the ground and remai motionless with legs and beak closely drawn against the body. When held, both sexes emit an audible squeaking sound by rub the abdomen against the inner surface of the wing covers.

LIFE CYCLE. Accounts of the weevil's life cycle differ, apparently because of climate. In coastal British Columbia, adults emerge during summer and early fall. Eggs are laid during two peak periods: March and April by adults that overwintered and July through September by newly emerged adults. Pupation occurs from mid-July through September after the larvae have overwintered.

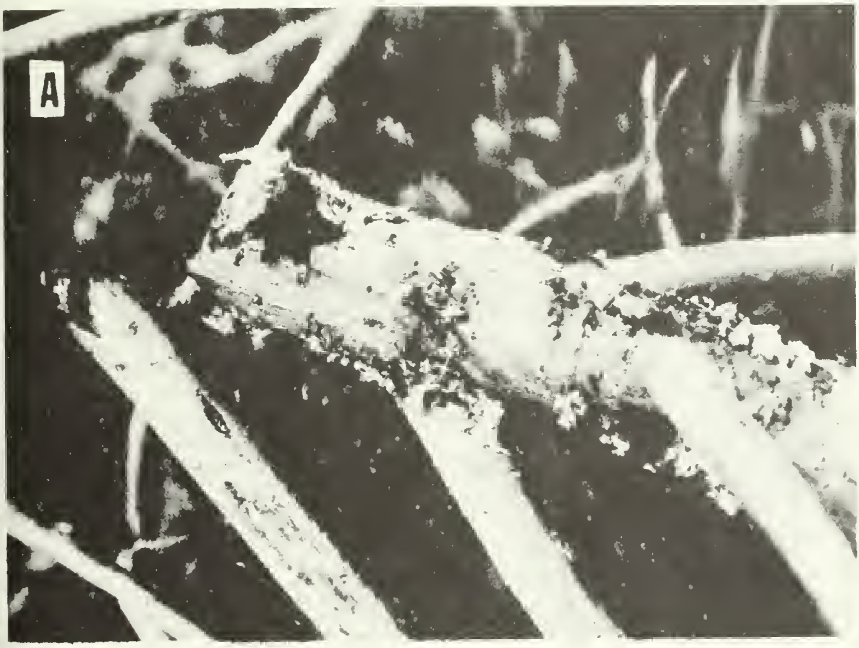
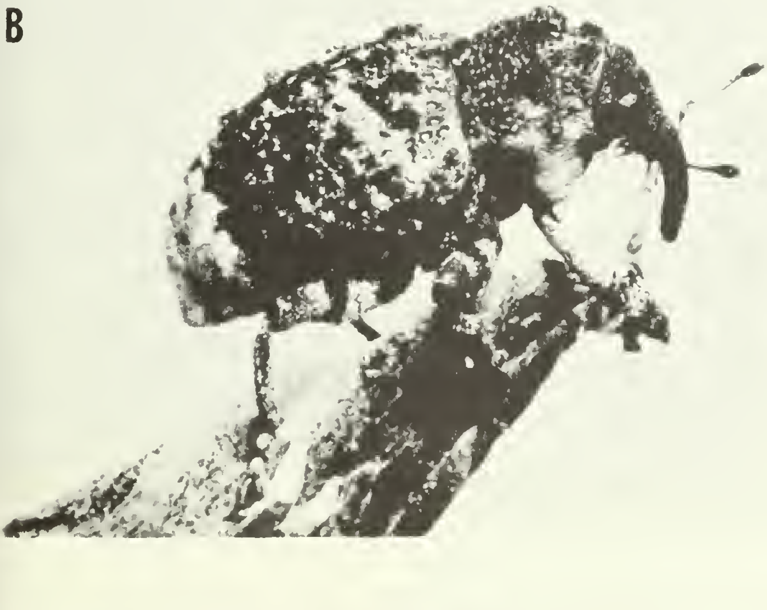


Figure 2.--A. Mining of willow stems by larvae of the poplar-and-willow borer subjects them to windbreakage. B. Adult weevil on bark where eggs are laid.



NATURAL CONTROL. The larvae are parasitized by an ichneumon wasp, *Dolichomitus messor sparsus* Townes.

References

Furniss, Malcolm M. 1972. Poplar-and-willow borer. USDA For. Serv., For. Pest Leafl. 121, 5 p.

Harris, J. W. E., and H. C. Coppel. 1967. The poplar-and-willow borer, *Sternochetus* (= *Cryptorhynchus*) *lapathi* (Coleoptera: Curculionidae), in British Columbia. Can. Entomol. 99:411-418.

Scolytidae: Bark Beetles

Chaetophloeus heterodoxus (Casey) (= *Renocis*): Mountain mahogany bark b

RANGE: Native to California, Nevada, Utah, Oregon, Monta Idaho, Washington, and British Columbia.

HOSTS: *Cercocarpus* commonly; reported on *Amelanchier* and

DAMAGE. Attacking beetles bore into the bark of the trunk and branches where they excavate oval egg chambers havin three to six fingerlike projections. The larvae deeply etch the wood during their mining (fig. 3). Usually, the infested trees have been injured previously by other agents such as sapsucking birds; however, during 1951-52 the beetle killed extensive stands of mountain mahogany in Oregon without eviden help. Infestations may persist in the same plant for several years.

APPEARANCE AND HABITS. The beetle is monogamous. From 6 to 12 eggs are laid in each projection of the adult chamber. The larvae are grublike, without legs. Their mines radiate from the egg chamber for three-fourths inch, tending not to overlap and increasing in width toward their ends where pupal cells are constructed. The pupal cells are mostly in the wood, an adaptation which apparently permits the beetle to inhabit thin-barked stems. The grayish-black adults are small, very stout beetles about 1.2-2.5 mm long. A sharp toothlike projection is present on the middle of the frons. The elytra are prominently striated lengthwise and basally ridged. Adult progeny exit through the bark, leaving circular holes three-fourths mm in diameter.

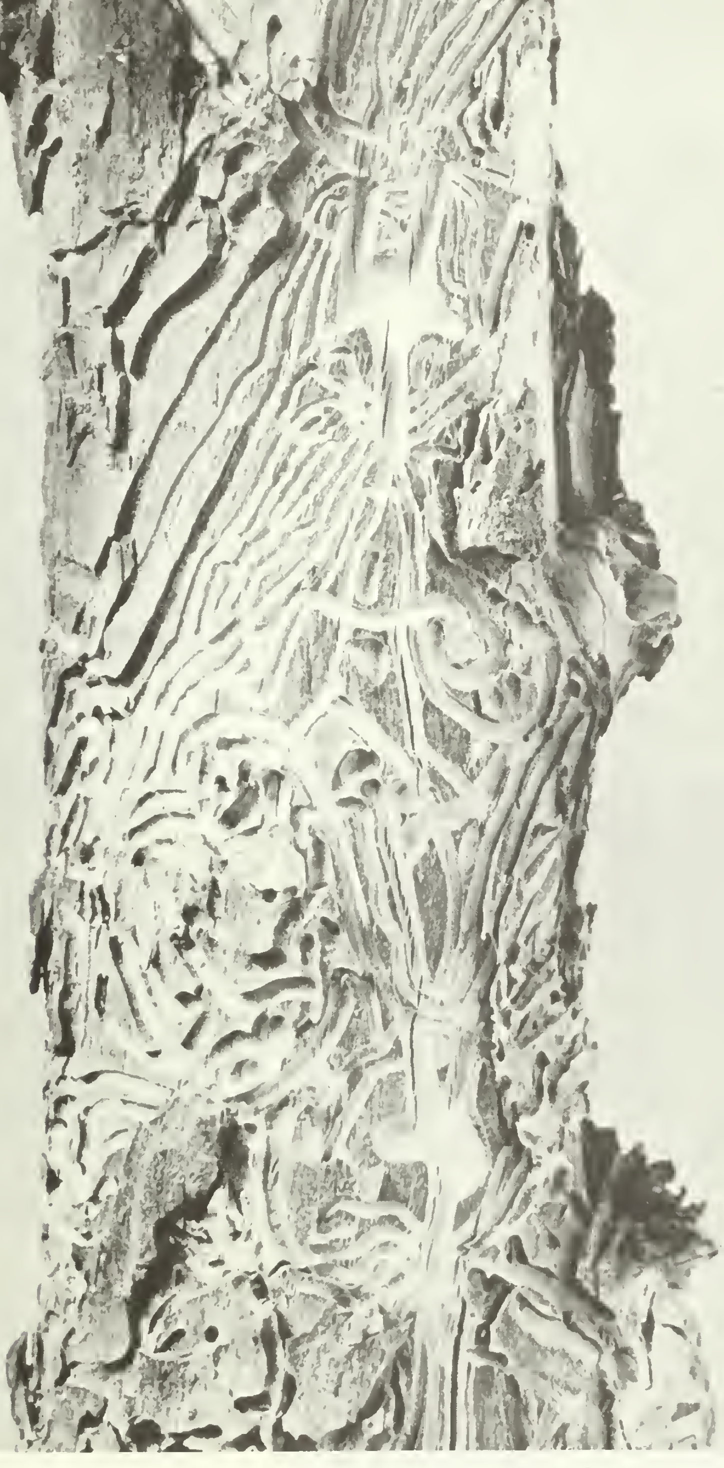


Figure 3.--This pattern was etched in the sapwood of mountain mahogany by the adults and larvae of the bark beetle, Chaetophloeus heterodoxus *(Casey).*

LIFE CYCLE. Adults apparently overwinter in their galleries and eggs are deposited in March. Larvae transform to pupae by May 15 and adults are present by June 1. Flight and construction of new egg chambers begin in late July. A second generation may occur but this has not been demonstrat

NATURAL CONTROL. The following wasps have been reared from infested stems and may be parasites of the mountain mahogany bark beetle: *Cephalonomia* sp. (Bethylidae), *Ecphyl hypothenemi* Ashm. (Braconidae), *Eurytoma phloeotribi* Ashm. (Eurytomidae), *Erythromalus* sp. (Pteromalidae), and *Karpinskiella* sp. (Pteromalidae).

References

Bright, D. E., Jr., and R. W. Stark. 1973. The bark and ambrosia beetles of California. Coleoptera: Scolytidae and Platypodidae. Univ. Calif. Press, Bull. Calif. Insect Surv. 16:1-169.

Chamberlin, W. J. 1955. Description of a new species of *Phloeosinus* and remarks regarding the life history and habits of *Renocis heterodoxus*. Pan-Pac. Entomol. 31:116-120.

Chamberlin, W. J. 1958. The Scolytoidea of the Northwest; Oregon, Washington, Idaho and British Columbia. Corvallis, Oreg.: Oreg. State Monogr., Studies in Entom 2, 208 p.

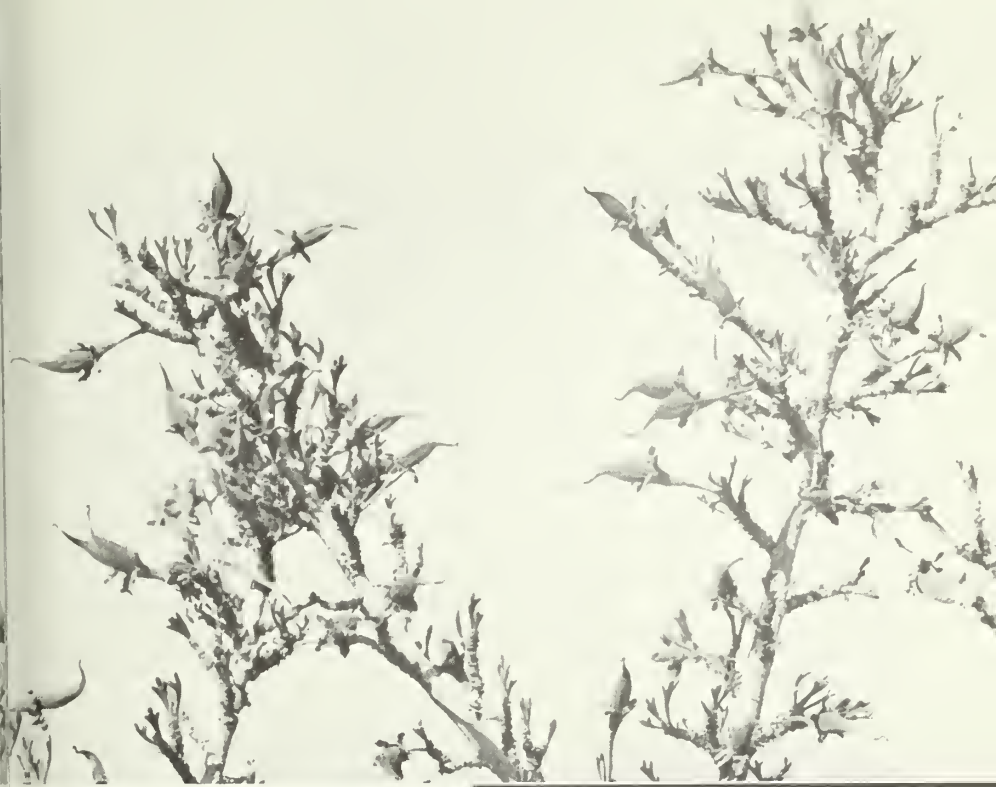
DIPTERA: FLIES

Cecidomyiidae: Gall Midges

***Mayetiola* sp. (= *Phytophaga*): Bitterbrush seed midge**

RANGE AND HOST. *Purshia tridentata* (Pursh) DC., in Idaho and Oregon.

DAMAGE. Larvae enter the base of the seed husk and complete their development between the husk and the seed. Infested seeds (fig. 4A) fail to develop normally in width and are retained on the plant overwinter, whereas healthy seed are plump and drop in early summer. In 1962, this midge destroyed 6.8 percent of a sample of seed examined east of Boise, Idaho.



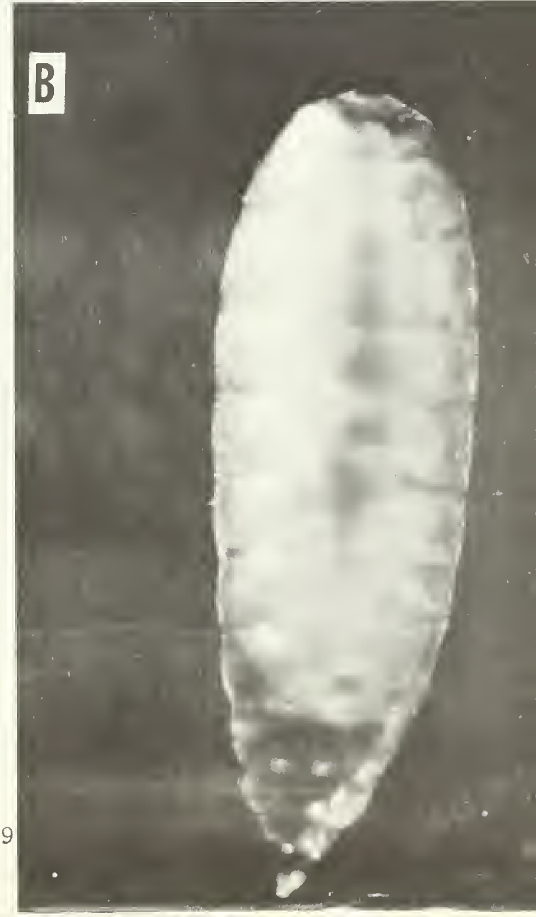


Figure 4.--Bitterbrush fruits infested with Mayetiola sp. *wither and persist on the plant (A) after normal seed drop. The "flax seed" stage (B) occurs within the seed husk and contains the last instar larva.*

APPEARANCE AND HABITS. One to several eggs are laid between the seed husk and its calyx tube. The legless, orange larva attains a length of 2 mm. It lacks a distinct head and its mouth parts are retracted, appearing only as a black spot. From one to several larvae may be present inside the husk of a single seed. They are usually accompanied by larvae of parasitic wasps, but these are paler in color. The shiny brown puparium (fig. 4B) is called the "flax seed" stage. The adult is difficult to rear and has not been positively associated with the immature stages. Adults of this genus are typically very small, delicately built flies with relatively long legs and antennae.

LIFE CYCLE. Eggs are laid in May. Naked larvae are present until the second week in June, after which they form puparia in which they pass the winter. Adults are believed to emerge in May and apparently survive for only a brief time.

NATURAL CONTROL. The eulophid wasps, *Aprostocetus* sp. and *Tetrastichus* sp. are common parasites of the larvae.

Reference

Ferguson, R. B., M. M. Furniss, and J. V. Basile. 1963. Insects destructive to bitterbrush flowers and seeds in southwestern Idaho. J. Econ. Entomol. 56:459-462.

Tephritidae: Fruit Flies

***Eutreta, Procecidochares,* and *Aciurina* spp.: Gall forming fruit flies**

RANGE. Widely distributed in western North America.

HOSTS. Commonly browseland shrubs, including species of *Artemisia* and *Chrysothamnus*.

DAMAGE. These insects cause galls to be formed on the buds, flowerhead, leaf axils, leaves, and branches or twigs. When abundant, they give the plant an unsightly appearance; they may also cause reduced growth and, in some instances, plant mortality.

APPEARANCE AND HABITS. Eggs are laid singly in or on plant tissue. A secretion from the ovipositing female or feeding larva is believed to cause a reaction by the plant which produces a specific kind of gall in which larval development occurs. The larva is small and maggotlike. The pupa is usually chunky, and enclosed in a dark brown cylindrical case within the gall. The adult is variable in size and appearance. Usually it has variegated or pictured wings but some species may have wings almost entirely black. The galls vary greatly in size and appearance. They may be hard, somewhat pearlike expansions of the small branches: e.g., *Eutreta diana* (Osten Sacken) on *Artemisia tridentata* Nutt.; cottony white swellings or flowerlike swellings of the buds; green flowerlike outgrowths of leaf axils; or sticky globular swellings attached to a stem: e.g., *Aciurina trixa* Curran on *Chrysothamnus nauseosus* (Pall.) (fig. 5). Many of the galls are similar to those formed by midges (Cecidomyiidae).

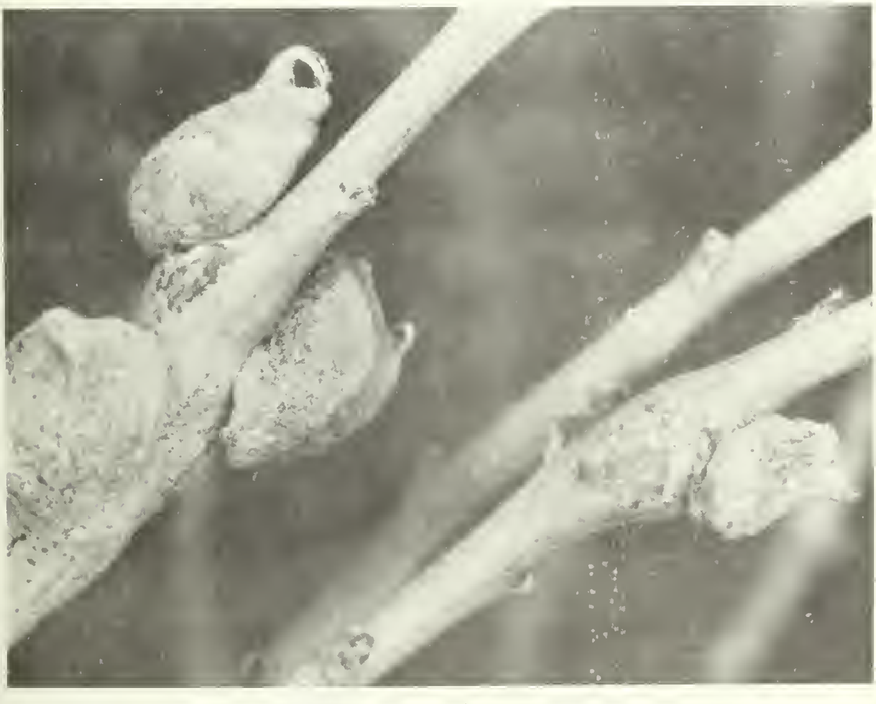


Figure 5.--Galls of the fruit fly, Aciurina trixa *Curran, on a branch of rubber rabbitbrush.*

LIFE CYCLE. The life cycle usually lasts 1 year, but two or more generations per year may occur. Adults are active for 1 to 4 weeks and occur at specific times of the year. Overwintering takes place as eggs or larvae. The pupal period lasts for 1 to 2 weeks.

NATURAL CONTROL. Many parasites of the larvae and pupa have been found. They appear to have considerable influence on population levels of the various species. In Idaho the following hymenopteran parasites have been reared from the galls of *Eutreta diana: Torymus* sp., *Eurytoma* sp., *Halticoptera stella* Girault, *Spilochalcis leptis* Burks, *Habrocytus* sp., *Eupelmus* sp., and *Tetrastichus* sp. The following have been reared from galls of *Aciurina* spp.: *Eupelmus* sp., *Tetrastichus* sp., *Torymus* sp., *Eurytoma* sp., *Halticoptera stella* Girault, *Amblymerus* sp., and *Bracon* sp.

Reference

Foote, Richard H., and F. L. Blanc. 1963. The fruit flies or Tephritidae of California. Univ. Calif. Press, Bull. Calif. Insect Surv. 7:1-117.

HEMIPTERA: TRUE BUGS

Pentatomidae: Stink Bugs

Chlorachroa sayi (Stäl): Say stink bug

RANGE. All western States and Alberta, Canada.

HOSTS. *Purshia tridentata* (Pursh) DC., grain crops, grasses and weeds.

DAMAGE. *C. sayi* punctures and sucks juice from develop bitterbrush seeds during late spring. These seeds develop necrotic spots and have only half the germination capacity of unspotted seeds. The stink bug also drastically reduces the yield of wheat and other grains by killing the seed heads of infested plants.

APPEARANCE AND HABITS. The egg is irregularly ovoid in shape, 1.2 mm long, 0.9 mm wide at the top, and 0.6 mm wide at the bottom. The top is marked in a bull's-eye pattern by circles of white and gray. From 20 to 50 eggs are deposited usually in a double row on stems, or in clusters if laid on larger surfaces such as a leaf. Incubation period averages 9 days. The top of the egg consists of a lid which is opened by the nymph with the aid of a chitinized shell burster. The nymphs pass through five instars varying in length from 1.1 to 10.6 mm. They have rather prominent four-segmented antennae (that of the adult is five-segmented). The first three instars are basically black with the shelflike lateral margins yellow, white, or red-orange in each of the first three instars, respectively. Additional areas of yellow-white occur dorsally. The last two instars are basically pale green; the margins are white with an orange edge. Wing pads first become evident in the fourth instar. The average total nymphal period is 43 days. The adult (fig. 6) is normally deep green color but varies from a pale yellowish green to reddish brown. During hibernation, its color changes to greenish pink. The rather long beak is hidden beneath the body and extends backward to the base of the hind legs. New adults do not oviposit for a month or more; late-developing adults do not oviposit

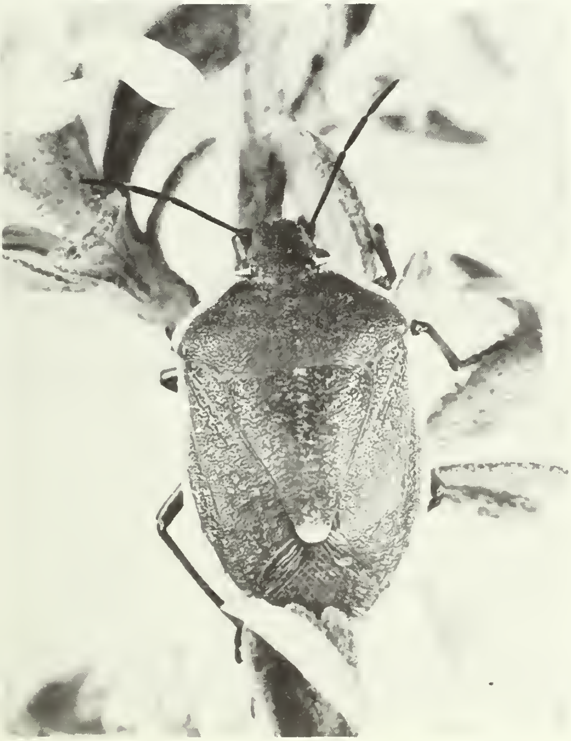


Figure 6.--An Adult Say stink bug on bitterbrush. Feeding by this bug lowers the viability of seed.

until the following spring. The adult is not easily flushed from its host and is a sluggish flier. If touched, it exudes a pungent-smelling liquid from two glandular openings near the attachment of the middle legs.

LIFE CYCLE. With the advent of cold weather in October or November, adults hibernate in protected places afforded by plant debris and rubbish. They emerge from hibernation during the first warm days of late April and early May. Eggs are laid soon thereafter. The resulting nymphs attain maturity about the last week in June. A second generation matures about the first week in August and establishes a third generation that matures about the middle of September. Most of the females of this last generation do not oviposit until the following spring.

NATURAL CONTROL. Winter kills any nymphs that have not matured before cold weather starts. Eggs are parasitized by the wasp, *Telonomus ashmeadi* Morril, and adults are parasitized by two tachinid flies, *Gymnosoma fuliginosa* Desv. and *Ocpterodes euchenor* Walk. The first two named parasites accounted for 60 percent of the eggs and 25 percent of the adults in one study, whereas *O. euchenor* was uncommon.

Reference

Caffrey, D. J., and G. W. Barber. 1919. The grain bug. U.S. Dep. Agric. Bull. 79, 35 p.

HOMOPTERA: APHIDS, LEAFHOPPERS, PLANTHOPPERS, SCALE INSECTS, and ALLIES

Coccidae: Soft Scales

Lecanium cerasifex Fitch: Bitterbrush tortoise scale

RANGE AND HOST. Occurs on *Purshia tridentata* (Pursh) DC. in Oregon, Idaho, and Montana.

DAMAGE. The female scale attaches herself to the host plant and feeds on sap by inserting her beak into a branch. Terminal branches that are heavily infested gradually die. The possibility that a plant disease is transmitted has not been studied.

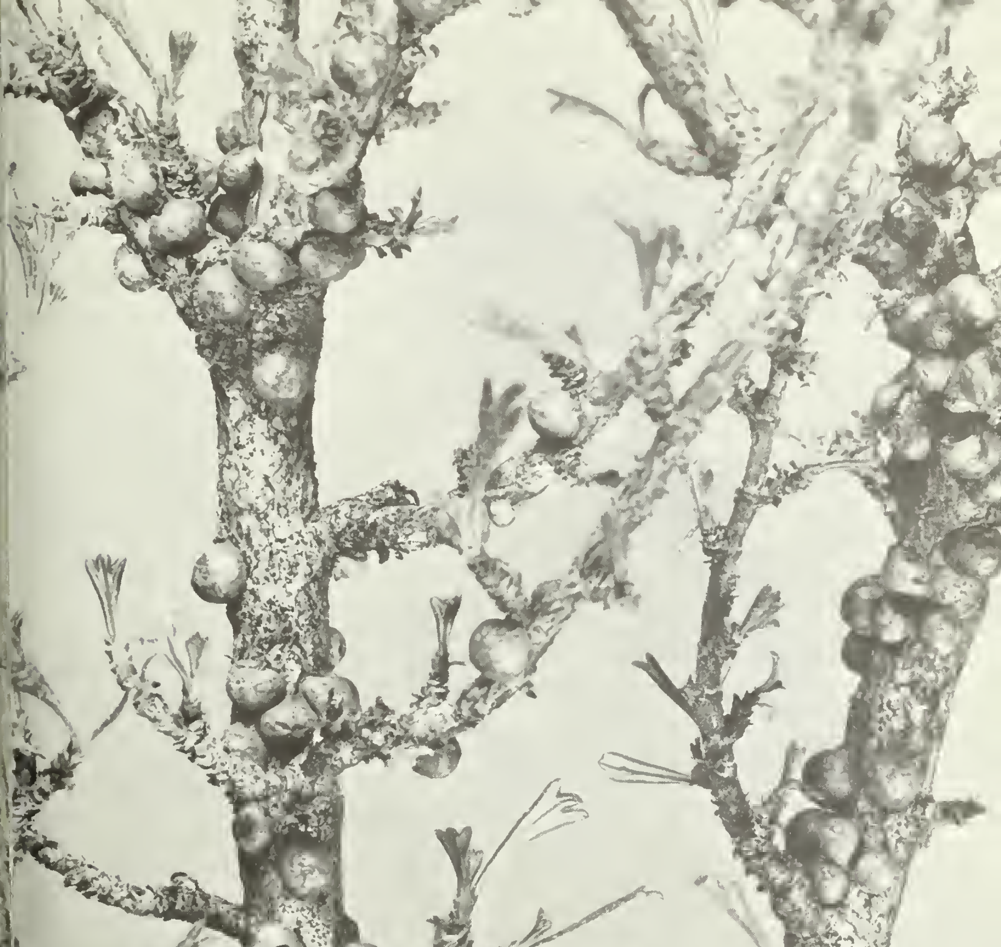


Figure 7.--The bitterbrush tortoise scale on bitterbrush stems. The females illustrated here are immobile and laden with eggs.

APPEARANCE AND HABITS. The scale has only recently been identified from bitterbrush and has not yet been studied in detail. The white, oval egg measures 0.3 by 0.2 mm More than 200 eggs are laid, hidden from view beneath the female while she is attached to a branch. The nymphs are mobile and are roughly 0.8 mm long. Their appendages are visible from above and the body is moderately elongated. The scales are probably disseminated in the nymphal stage by wind. The adult female (fig. 7) is nearly hemispherical, 33 to 40 mm long, and 25 to 33 mm wide. She is immobile, though possessing inconspicuous appendages, and remains closel attached to the branch for the duration of her life. Viewed dorsally, the posterior of the female has a small slit, possibly used as an exit by the newly hatched nymphs. During egg laying, the female integument is somewhat frosty in appearance but becomes shiny brown thereafter. Infested branches are moist with honeydew or sap in springtime. Ants and ladybird beetles search out and feed on this liquid.

LIFE CYCLE. The scale apparently has one generation per year. Eggs are laid in May. Time of hatching and attainment of other stages have not been studied.

NATURAL CONTROL. An unidentified small wasp commonly parasitizes the scales.

Diaspididae: Armored Scales

Lepidosaphes ulmi (Linnaeus): Oystershell scale

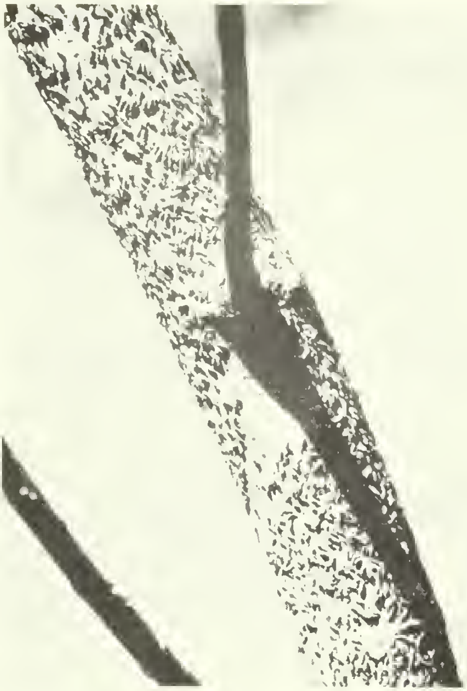
RANGE. A cosmopolitan insect; introduced into North America many years ago. It can be found in all the western States and Canadian provinces.

HOSTS. *Salix*, *Amelanchier*, *Rosa*, and many other kinds of shrubs and trees.

DAMAGE. Adults on limbs and branches suck the sap and may partially or completely kill the host plant.

APPEARANCE AND HABITS. The tiny cylindrical eggs are deposited and retained under the protective scale of the female. Twenty to 100 are usually present. Newly hatched nymphs or crawlers are pale in color, flattened, and have short legs and antennae. Characteristic structural parts are lacking. After wandering over the bark surface of the host, the nymph inserts its long slender mouth parts or stylets

Figure 8.--Adult female oystershell scales on stem of willow.



into plant tissue and then settles down for a sedentary life. A characteristic waxy secretion is deposited over the body. The adult male and female are considerably different in appearance. The female resembles the nymph but has a scaly covering that is gray to brown, slightly annulated, and shaped like an elongate oystershell (fig. 8). It is approximately one-eighth inch long. The male undergoes a metamorphosis and upon emergence resembles a tiny fragile fly with two wings but with aborted mouth parts and elongate antennae. Males are rare and parthenogenetic reproduction may be the rule for this species.

LIFE CYCLE. One to two generations per year occur in this area depending upon local conditions. The eggs are the overwintering stage.

Reference

Graham, S. A., and F. B. Knight. 1965. P. 283-285, in: Principles of Forest Entomology, 4th ed. 417 p. McGraw-Hill, New York.

Ortheziidae: Ensign Scales

***Orthezia artemisiae* Cockerell: Sagebrush orthezia**

RANGE. California, New Mexico, Nevada, Washington, and Idaho.

HOSTS. Several species of sagebrush, *Artemisia tridentata* Nutt., *A. tripartata* Rydberg, and *A. californica* and others.

DAMAGE. Branches are killed or weakened when large numbers of individuals are present. No extensive plant mortality is known.

APPEARANCE AND HABITS. The mature female is covered with long, fluted, white waxy secretions that also enclose the egg sac. Total length is approximately 10 mm. Partially grown crawlers are covered with a white waxy secretion and have a characteristic fringe of wax around the body. The mature female is most often found on the upper branches of the host plant and is tended by ants which collect honeydew from her. In Idaho, two species of ants, *Formica* sp. and *Dorymyrmex paramicus* (Roger), have been associated with this orthezian.

LIFE CYCLE. Not known.

Reference

Morrison, Harold. 1952. Classification of the Ortheziidae. U.S. Dep. Agric. Tech. Bull. 1052, 80 p.

HYMENOPTERA: ANTS, BEES, SAWFLIES, WASPS, and ALLIES

Formicidae: Ants

***Pogonomyrmex occidentalis* (Cresson) and *P. owyheei* Cole: Western harvester ant and owyhee harvester ant**

RANGE. Semiarid parts of the Northwest.

HOST. Sagebrush communities, where they defoliate numerous annual and perennial plant species, including *A. tridentata.*

DAMAGE. These ants clear circular areas up to 30 feet in diameter of all annual vegetation and may then defoliate and kill shrubs in the clearing. Up to 8 to 10 percent of a rangeland site may be denuded by these ants. They also devour seeds.

APPEARANCE AND HABITS. An underground nest is located within the center of the cleared area. The nest may have several entrances, usually associated with a small mound of soil and pebbles. Within the nest all developmental stages of the ant can be found. The larvae are small, shiny white, and maggotlike in appearance. Pupae are enclosed in a tannish parchmentlike covering, through which they are not discernible. Adults are moderate size, uniformly reddish brown, and indistinctly clothed with fine, pale hairs. The sexual forms are winged.

LIFE CYCLE. A colony is active throughout the year, although much of the activity is beneath the soil surface and is greatly influenced by temperature and moisture. An annual brood of winged adults is produced which fly in late June or early July. The workers can inflict painful stings on man and livestock.

References

Crowell, H. H. 1963. Control of the western harvester ant, *Pogonomyrmex occidentalis*, with poisoned baits. J. Econ. Entomol. 56(3):295-298.

Lavigne, Robert J., and Herbert G. Fisser. 1966. Controlling western harvester ants. Mt. States Reg. Publ. 3, 4 p.

Sharp, Lee A., and W. F. Barr. 1960. Preliminary investigations of harvester ants on southern Idaho rangelands. J. Range Manage. 13(3):131-134.

LEPIDOPTERA: MOTHS, BUTTERFLIES, SKIPPERS

Ethmiidae: Ethmiid Moths

Ethmia discostrigella (Chambers): Mountain mahogany leaf notcher

RANGE. California, Oregon, Idaho, Nevada, Utah, Colorado, Arizona, New Mexico, western Texas, northern Chihuahua, and Baja California.

HOSTS. *Cercocarpus ledifolius* Nutt., *C. montanus* Raf. and *C. minutiflorus* A. Gray.

DAMAGE. Feeding by the larvae creates irregular notch in the leaf edges but leaves are seldom completely consumed.

APPEARANCE AND HABITS. The egg is pink, 1.2 by 6 mm, oval, flattened, and somewhat irregular in outline. Hatchi occurs in about 10 days at room temperature. The mature larva may attain 19.5 mm in length and has either a dark orange or yellow dorsal band. Its head capsule is orange, and the remainder of the body is either mottled blackish or mottled pale gray. Pupation occurs within a dense, flat, white cocoon in litter, bark, hollow annual plants, etc. The pupa is brown, 8 to 9 mm long, flattened, and has charac teristic "anal legs" anchoring it to the cocoon. The adult is attractively colored and marked. Its wingspan is 20 to 25 mm. The forewings, head, and pronotum are gray with distinct black submarginal spots along the outer wing and a few elongated black spots along the center of the wing and on th sides of the pronotum. The tips of the forewings are silver and one silver spot occurs toward the center. The hind wing and abdomen are a beautiful satiny gold. Adults are nocturn and are attracted to light. Oviposition occurs at dusk and after dark on fibrous surfaces.

LIFE CYCLE. Moths fly during June at which time eggs are laid. Larvae are present from July through mid-Septembe Winter is passed in the pupal stage.

NATURAL CONTROL. Natural control factors are unknown except for two ichneumon wasps, *Meteorus* sp. and *Temelucha* sp., reared from parasitized larvae.

Reference

Powell, J. A. 1971. Biological studies on moths of the gen *Ethmia* in California. J. Lepid. Soc. 25 (Suppl. 3):46-

Gelechiidae: Gelechiid Moths

Aroga websteri Clarke: Sagebrush defoliator

RANGE. Northern California, eastern Oregon and Washington, southern Idaho, Nevada, Utah, and portions of wester Montana.

HOSTS. *Artemisia tridentata* Nutt., *A. longiloba* Osterhout, *A. tripartata* Rydberg, *A. nova* Nelson *A. arbuscula* Nutt., *A. rigida* (Nutt.) Gray, *A. cana* Pursh, and others.

DAMAGE. Big sagebrush is most seriously affected under low or moderate population densities of the moth. Individual plants are partially or entirely killed through defoliation. Under high population densities, entire stands involving thousands of acres of the host plant may be eliminated.

APPEARANCE AND HABITS. The eggs are globular, white to yellowish, and approximately one-half mm in diameter. They are deposited singly or in small groups on the bark of terminal stems of the host plant, but are rarely seen. The larva is creamy white to greenish with a dark head and prothoracic shield and small dark spots on the sides of the body segments. Mature larvae are approximately 12 mm long. Newly hatched larvae mine the leaves of the host; as they mature they enclose leaves and terminal branches in a mass of webbing in which they live and feed. When disturbed, a larva drops from its webbing and hangs by a silken thread. The pupa is smooth, brown, strongly pointed at its apex, and 7 to 10 mm long. Pupation takes place in the larval webbing. Adults are small gray moths with a wingspan of about 15 mm. The front wings are gray with or without small conspicuous black markings. The hind wings are paler and have a fringe of long gray hairs along the hind margin. The adults are secretive and primarily nocturnal, but will fly when disturbed during the day. They are attracted to lights.

LIFE CYCLE. There is one generation per year. Eggs or tiny larvae overwinter and resume their development during the spring and early summer. Pupation, which lasts from 3 to 4 weeks, takes place in late June and early July. Adults live for 2 to 3 weeks.

NATURAL CONTROL. Twenty species of hymenopterous parasites have been associated with the sagebrush defoliator in Idaho. Of these, an encyrtid, *Copidosoma bakeri* (Howard); an ichneumonid, *Phaeogenes arogae* Gittins and Henry; and a chalcidid, *Spilochalcis leptis* Burks, are the most abundant. They attack the larva. The moth and the larva are preyed on by two beetles, a clerid, *Phyllobaenus subfasciatus* (LeConte), and a carabid, *Philophuga amoena* LeConte.

References

Fillmore, O. O. 1965. The parasitoids of *Aroga websteri* Clarke (Lepidoptera: Gelechiidae) in southern Idaho. M.S. Thesis, Univ. Idaho, 129 p.

Hall, Ralph C. 1965. Sagebrush defoliator outbreak in northern California. U.S. For. Serv. Res. Note PSW-75, 12 p

Henry, J. H. 1961. The biology of the sagebrush defoliator *Aroga websteri* Clarke in Idaho (Lepidoptera: Gelechiida M.S. Thesis, Univ. Idaho, 58 p.

***Filatima sperryi* Clarke: Dark bitterbrush leaf tier**

RANGE AND HOST. Idaho and Montana on *Purshia tridentat* (Pursh) DC.

DAMAGE. Damage is similar to that caused by *Gelechia mandella* Busck. and both may occur on the same plants. Youn larvae destroy seed by mining through the husk and feeding within the seed. In a local area of southwestern Idaho, 5.2 percent of the seeds were lost in this manner during 1961. After emerging from the seed, larvae cause additional damage by feeding on foliage of the shrubs.

APPEARANCE AND HABITS. The egg has not been observed. The mature larva is 14 mm long and has a shiny black head capsule, prothoracic shield, and anal plate. The body has six dark brownish stripes running lengthwise. The young larva mines into a seed husk at its middle and plugs the entrance hole with silk which protrudes outward (fig. 9). When through feeding, the larva exits through a clear openin often near the apex of the husk. Thereafter, the larva constructs a silken tube, open at both ends, which may web together several leaves. If disturbed, a larva emerges backward from its tube by rapid, erratic movements. The pupa is formed within a white silken cocoon in webbing on the plant. The adult moth has a wingspan of 15 to 19 mm. Moths appear to be rather uniform dark brown, but under magnification the forewings are somewhat mottled orange and brown on their upper surface. The forewings are darker than the hindwings and the trailing edge of the latter is adorned with a fringe of feathery scales which are nearly as long as the width of the hindwing. Maxillary palps form hornlike processes that curve forward and upward from beneath the head. The moths are active at night.

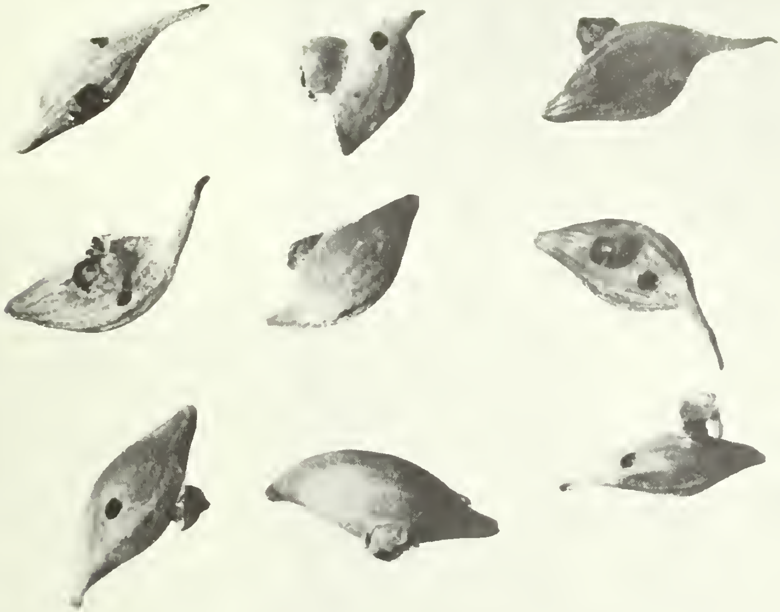


Figure 9.--Bitterbrush fruit damaged by mining of caterpillars of Filatima sperryi *Clarke. The entry holes are plugged with silk secreted by the larvae.*

LIFE CYCLE. Eggs are probably laid beginning in mid-August and winter is probably passed in this stage on the plant. Larvae are present from early June until early August when pupation occurs. Adults are in flight from mid-August until September.

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Ferguson, R. B., M. M. Furniss, and J. V. Basile. 1963. Insects destructive to bitterbrush flowers and seeds in southwestern Idaho. J. Econ. Entomol. 56:459-462.

***Gelechia mandella* Busck: White-collared leaf tier**

RANGE AND HOST. Arizona, Idaho, Montana, and Alberta on *Purshia tridentata* (Pursh) DC.

DAMAGE. First instar larvae mine seeds and destroy them. Later instars feed on leaves which are webbed togethe and retained on the plant. Infested plants are at their worst in appearance in late August. Damage was especially notable in Valley County, Idaho, during 1962 and in Ravalli County, Montana, in 1968. The long-term effect of damage by this leaf tier has not been assessed.

APPEARANCE AND HABITS. The egg has not been observed. Larvae range in size from 2 mm in the first instar to 12 mm when mature. The head and thoracic shield are shiny black The mesothorax is bordered by two conspicuous white bands and the body is green with seven cream colored stripes runnin lengthwise. Larvae of all instars have an anal comb consisti of two prominent recurved spines. First instar larvae mine seed (fig. 10); older larvae construct webs, open at both ends, through which they emerge to feed. When disturbed, larvae wriggle violently backward from their webs, and are sometimes called "nervous worms." The pupa is formed within a white cocoon on the plant. Wing span of the adult is 7 to 9 mm. Background color of the moth is dark grayish brown. The front wings have three or four black dashes running lengt wise along their middle area. The trailing edges of both pairs of wings are feathery. The maxillary palps are hornlik and curve forward and upward from the underside of the head. Adults fly at night and are attracted to light.

LIFE CYCLE. Eggs are apparently laid during late August The winter is probably passed in this stage but possibly small larvae may overwinter. Larvae have been collected from early June until early August, at which time pupation begins. Adults appear from mid-August to early September.

NATURAL CONTROL. Larvae are parasitized by a tachinid fly, *Nemorilla* sp., and braconid wasps, *Agathis* n.sp. and *Chelonus* sp.

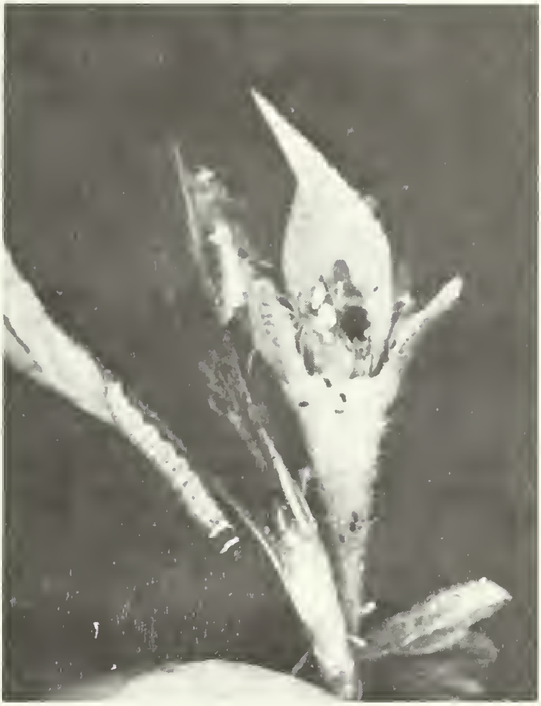
Geometridae: Measuringworms or Loopers

Anacamptodes clivinaria profanata (Barnes and McDunnough): Mountain mahogany looper

RANGE. Eastern California, Oregon, Washington, British Columbia, Idaho, Utah, and western Colorado.

HOSTS. *Cercocarpus ledifolius* Nutt. and *Purshia tridentata* (Pursh) DC.

Figure 10.--A caterpillar of Gelechia mandella *Busck. beside bitterbrush fruit which it had infested.*



DAMAGE. Defoliation by the loopers (fig. 11A) is capable of killing host plants extensively in relatively pure stands. In a 3-year outbreak, ending in 1964, loopers killed 50 percent of a 6,000-acre stand of mountain mahogany in southwestern Idaho. In 1957, they similarly killed bitterbrush in north central Oregon. Normally, they are present in small numbers and such destructive outbreaks are rare.

APPEARANCE AND HABITS. The green eggs are laid abundantly (70 to 716 per female) in crevices but are rarely seen. The larva (fig. 11B) is a typical looper and varies in length from 2.3 to 33.0 mm from the first to the fifth (last) instar. The larva's protective coloration and form, coupled with its habit of resting motionless in a crotchlike position, make it difficult to see. Color of larvae varies. On mountain mahogany, they tend to be marked with black against a cream, or sometimes orange-brown background. Larvae on bitterbrush are rather uniform gray. Pupation occurs in the soil beneath infested trees. The pupa is naked, stout, and shiny brown and has a four-tined spadelike process

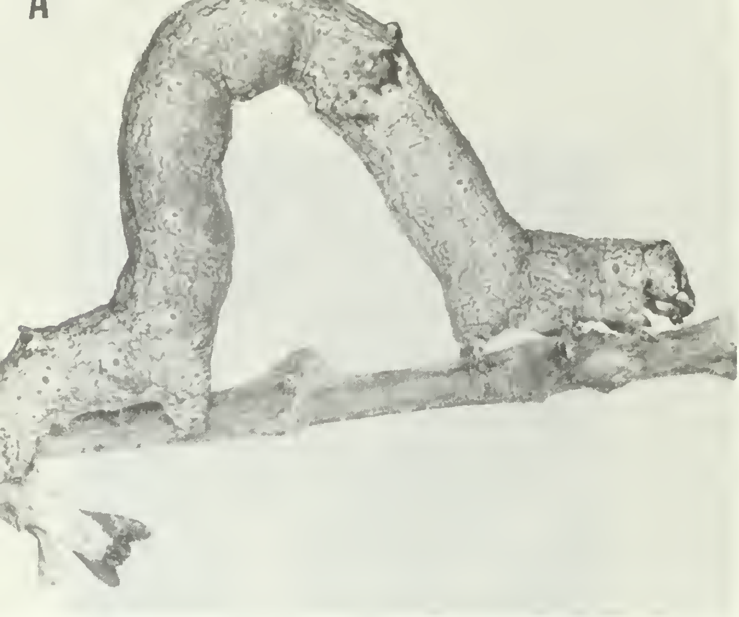
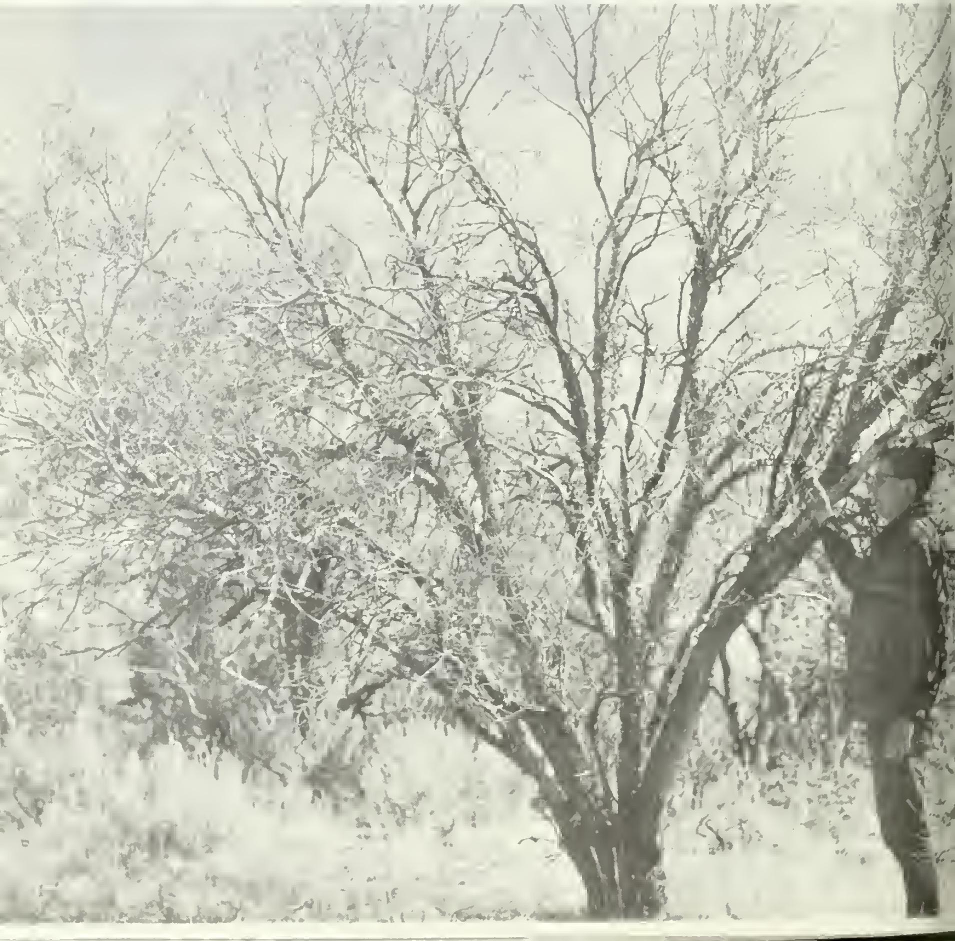


Figure 11.--
Loopers (A)
of Anacampt
clivinaria
fanata *(B. a*
McD.) occasi
ally severel
defoliate st
of mountain
mahogany (B)



(cremaster) at its posterior. The adult moth is grayish with subdued black and brown markings. Males are somewhat more contrastingly marked, are more active, and have featherlike, rather than filamentlike, antennae. Wingspan is 27 to 36 mm. In daytime they rest on the trunk of the host but are active at night.

LIFE CYCLE. Eggs are laid in June after adult moths emerge from the soil. The looper larvae appear from early July to mid-August, when they drop to the ground on silk threads to pupate in the soil and spend the winter.

NATURAL CONTROL. Parasites of the pupae include a tachinid fly, *Blondelia* (sp. n.?), an ichneumon wasp, *Melanichneumon* sp., and the pteromalid wasps, *Tritneptis* sp. and *Cyclogastrella deplanata* (Nees.). The first two named parasites seem rare; the others are more common and are multiple parasites; as many as 85 *Tritneptis* emerged from one host pupa. Starvation played a large part in the subsidence of an observed outbreak in southwestern Idaho.

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Lasiocampidae: Tent Caterpillars

***Malacosoma* spp.: Tent caterpillars**

RANGE AND HOSTS. Five species and 11 subspecies of these caterpillars occur on numerous kinds of shrubs and trees in the West. Three species are covered here.

DAMAGE. Tent caterpillars cause severe defoliation resulting in decline of vigor accompanied by dieback of branches and up to 90 percent reduction of radial growth. Defoliation seldom occurs more than 2 or 3 years in successi but may kill the plants. The caterpillars are a nuisance in some recreational areas.

GENERALIZED APPEARANCE AND HABITS. All species overwinter in egg masses attached to the host plant. Hatching coincides with formation of the first new leaves. Larvae of several species build large tents (fig. 12A) in which they remain when not feeding. The larval stage lasts 4 to 8 weeks, depending on weather conditions. When larvae mature, they are 50 to 65 mm long and they lose their gregarious habit. Pupation occurs within silken cocoons (fig. 12B), spun on the host plant; cocoons are about 1 inch long and are dusted with white or yellowish powder. Adults appear 10 to 1 days after pupation and are active in the evening. Wingspan of males is 25 to 30 mm; that of females is 30 to 35 mm. The antennae of males are featherlike while those of females are filiform. Adults lack functional mouth parts and live only a few days.

LIFE CYCLE. Tent caterpillars have one generation per year.

NATURAL CONTROL. Outbreaks are frequently reduced to a low level by nuclear polyhedrosis virus, by numerous species of parasites and predators, by starvation, and by prolonged unfavorably low temperatures. Among the parasites, the sarcophagid fly, *Sarcophaga aldrichi* Parker, is reported to hav been important in suppressing *M. distria* in Minnesota.

Malacosoma distria Hübner: Forest tent caterpillar

RANGE. Throughout the deciduous forests of the United States and Canada.

HOSTS. Nearly all species of deciduous trees are fed upon. *Populus tremuloides* Michx. is a preferred host but other species of *Populus*, as well as *Quercus*, *Alnus*, *Salix*, *Betula*, and *Acer* (except red maple) are also commonly defoliat

DAMAGE. Defoliation results in decline of tree vigor manifested by killing of branches and reduction of radial growth. In Minnesota, up to 80 percent of the aspen trees

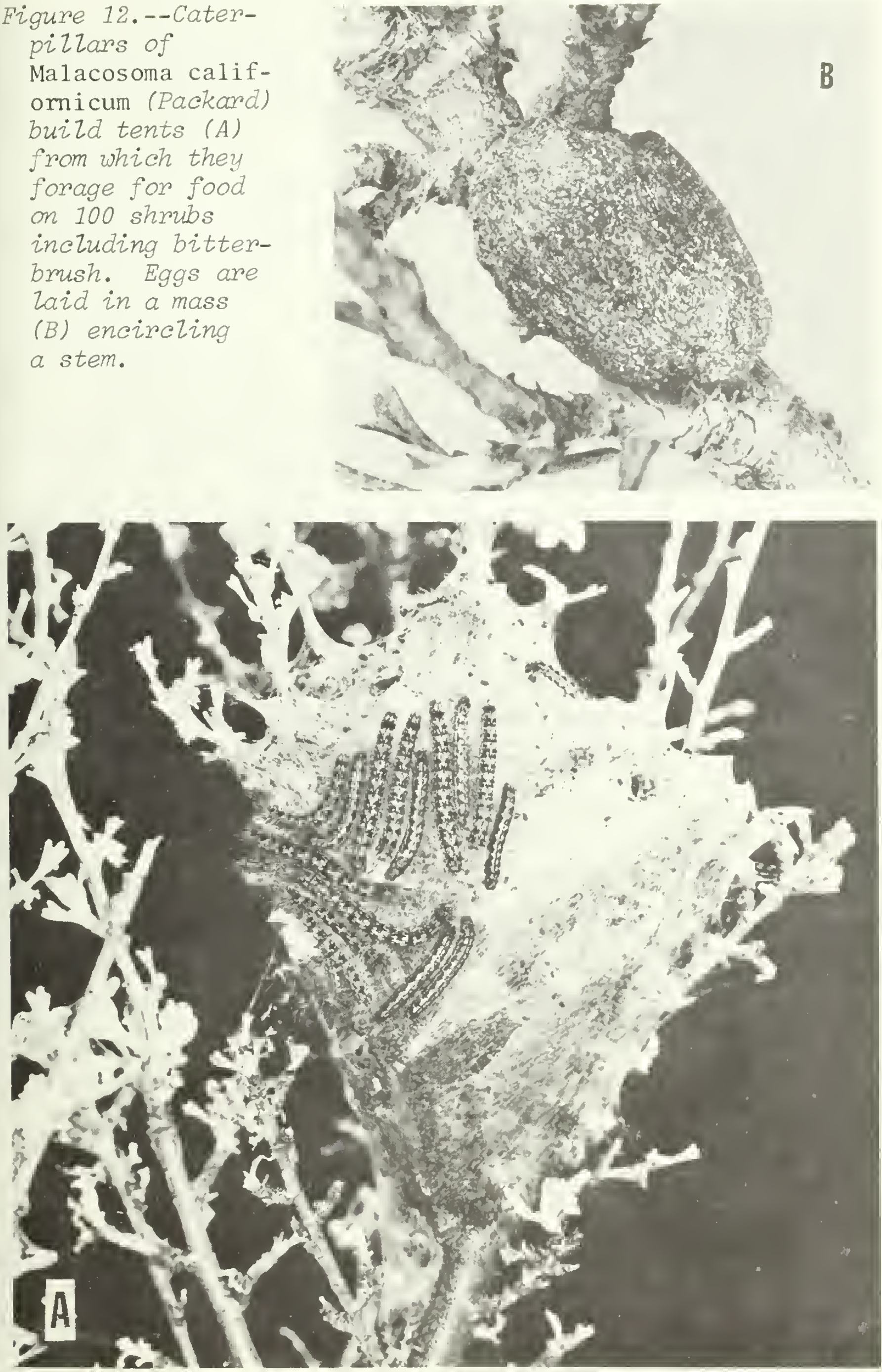

Figure 12.--Caterpillars of Malacosoma californicum *(Packard) build tents (A) from which they forage for food on 100 shrubs including bitterbrush. Eggs are laid in a mass (B) encircling a stem.*

died following 4 or 5 years of repeated defoliation. Such prolonged outbreaks have not been reported in the West, but during 1963-64, especially severe defoliation occurred in the Idaho panhandle area where 116,000 acres of hardwoods were infested along river bottomland.

APPEARANCE AND HABITS. Eggs are laid in a helical mass of 100 to 350 eggs encircling a twig of up to one-half inch diameter. The egg mass is cylindrical with flattened ends and the eggs are cemented together with a frothy glue-like substance (spumaline), which is glossy dark brown. Newly hatched larvae are uniformly black and have conspicuous hairs. Mature larvae are blue, black, and gray with a somewhat keyhole-shaped dorsal spot on each segment, and with some yellowish or orange broken longitudinal lines. The caterpillars do not build silken nests but molt on thin mats of silk spun on branches. The cocoon is often spun between leaves and is suffused with a lemon-yellow powder. The adult is light buff brown and has a stout body. The forewings have two dark oblique lines near the middle.

Malacosoma californicum (Packard): Western tent caterpillar

RANGE AND HOSTS. Throughout western and northern North America. Six subspecies are distributed around the periphery of a large central population. They include two subspecies (*M. californicum pluviale* (Dyar) and *M. californicum fragile* (Stretch) that were formerly considered to be separate species.

The central population of *M. californicum* (Packard) occurs in a large heterogeneous area including most of the Great Basin, the Rocky Mountains within the United States, the mountains of the Southwest, eastern Oregon and Washington, and parts of northern California. It infests many hosts, including *Purshia tridentata* (Pursh) DC., *Ceanothus, Salix, Cercocarpus, Rosa, Ribes, Amelanchier, Populus tremuloides* Michx., and others. Particularly severe defoliation has been recorded on bitterbrush in the Great Basin, and on aspen at higher elevations in Colorado, New Mexico, Arizona, and Utah. In New Mexico, damage caused by caterpillars has prevented the growing of aspen commercially.

M. californicum pluviale (Dyar) occurs west of the Cascades in Oregon and Washington, and in the northern Rockies west of the Continental Divide, as well as in the boreal forests of Canada east to Quebec and in the northern fringes of the Lake States. Common hosts are *Alnus, Salix,* fruit trees, and various other Rosaceae.

APPEARANCE AND HABITS. The highly variable life stages of this species make meaningful descriptions difficult. As a rule, any tent caterpillar found west of the Central Plains which builds a large tent is probably some form of *M. californicum* unless it occurs along watercourses or at lower elevations in the Southwest where *M. incurvum* is found. Eggs are laid in a mass partially encircling twigs and are covered with a grayish to brownish spumaline. The adult is basically yellowish to brownish with a pair of contrasting lines across the forewings.

Malacosoma constrictum (Henry Edwards): Pacific tent caterpillar

RANGE AND HOSTS. Western Washington and Oregon, California, and Baja California. The subspecies *M. constrictum constrictum* (Henry Edwards) occurs in the Pacific Northwest and to the San Bernardino and San Gabriel Mountains of California. It oviposits on *Quercus* and defoliates it, but the older larvae may feed on many other trees and shrubs.

APPEARANCE AND HABITS. Eggs are laid in a helical band completely encircling small twigs. The eggs are covered with bright yellow spumaline composed of large transparent bubbles. Mature larvae are predominantly whitish laterally and blue-white dorsally with no middorsal marks, but each segment has an hourglass-shaped dorsal orange blotch with a black spot on either side of the neck of the hourglass. Dorsal setae are orange and lateral setae are white; both are conspicuously tufted. Black markings are mixed with the other colors. Small tents are made by the larvae prior to molting. Cocoons are fairly tightly constructed, have no outer envelope of silk, and are dusted with a white powder. Adult males are usually light yellow, with wings crossed by two dark lines, the outline usually meeting the anterior margin at a right angle. Females are usually dark reddish-brown, dusted with whitish-yellow scales.

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Lymantriidae: Tussock Moths

Hemerocampa vetusta gulosa (Boisduval): Western tussock moth

RANGE. California, Nevada, Oregon, Washington, Idaho, and British Columbia.

HOSTS. *Purshia tridentata* (Pursh) DC., *Salix*, *Arctostaphylos*, *Quercus*, and numerous kinds of fruit trees.

DAMAGE. The caterpillars feed on leaves and fruit, causing much damage. Healing of the feeding injury on young apples gives a scabby appearance and lowers their market value During 1958-59 and 1963-64, extensive areas of bitterbrush wer severely defoliated in the vicinity of Reno and Carson City, Nevada. Some twigs were killed. In 1957, this insect was rated as the most economically important orange-worm pest on citrus in California. In that year, approximately 10,000 acres of citrus were infested with caterpillars varying in number from 30 to 1,000 per tree. Within a 6-week period, heavy infestation may destroy all the new spring flush of growth and up to 80 percent of the newly set fruit.

APPEARANCE AND HABITS. The egg (fig. 13A) is 1.2 mm in diameter and is opaquely white. The shell is rather tough and is depressed at one end. Eggs are laid in closely matted, white, felty masses upon the old cocoons. The majority of egg masses are deposited on stems within a foot above ground. During oviposition, the female is atop the egg mass as though she were attempting to brood it or protect it as a hen would her eggs. The mature caterpillar (fig. 13B) attains a maximum length of 22 mm and is black with numerous bright red and yellow tubercular spots; each red spot is the source of long, radiating gray-white hairs. There are four median-dorsal tufts, uniform honey color or whitish, sometimes tipped with black, and two long anterior black tufts and one posterior black hornlike tuft. When small, the hairy caterpillars are dispersed by wind. The cocoon is loosely composed of grayish-white silk and incorporates many of the larval hairs. The male pupa is 12 mm long, glossy, translucent brownish black, with the wing pads coming down to the abdominal segments, and the conspicuous featherlike antennae curving down from the head like a ram's horns. The female pupa is about 16 mm long, glossy, translucent light yellowish brown, with shorter wing pads and less conspicuous antennae; the short airlike antennae curve down and parallel the palpi. The female moth is 12-15 mm long when gravid but much smaller after oviposition has occurred. She lacks the ability to fly, having only rudimentary wings. Her integument is glossy black and is almost completely covered with long, wavy pinkish-gray hair. The adult male is winged, with an expanse of 20 to 27 mm. It is generally brownish with grayish-white and dark brown markings. At rest, its wings form a triangular outline from above.

LIFE CYCLE. A single generation occurs per year in most locations, although there may be two in southern California. Depending on climate of the area, adult moths are present from May through July, during which time eggs are laid. In Idaho and Nevada, eggs are laid only in July.

NATURAL CONTROL. The eggs are parasitized by two wasps: *Ooencyrtus californicus* Girault (Encyrtidae) and *Telenomus*

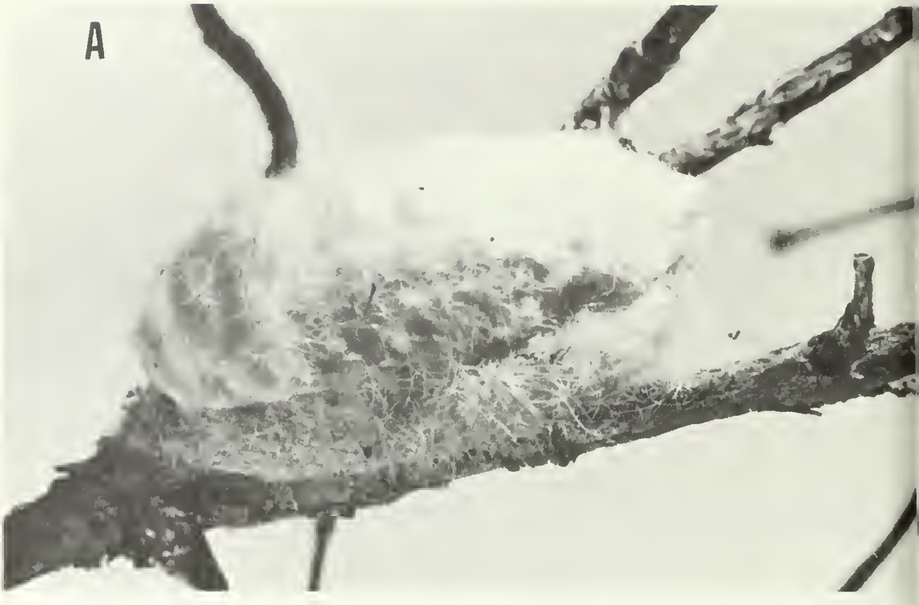
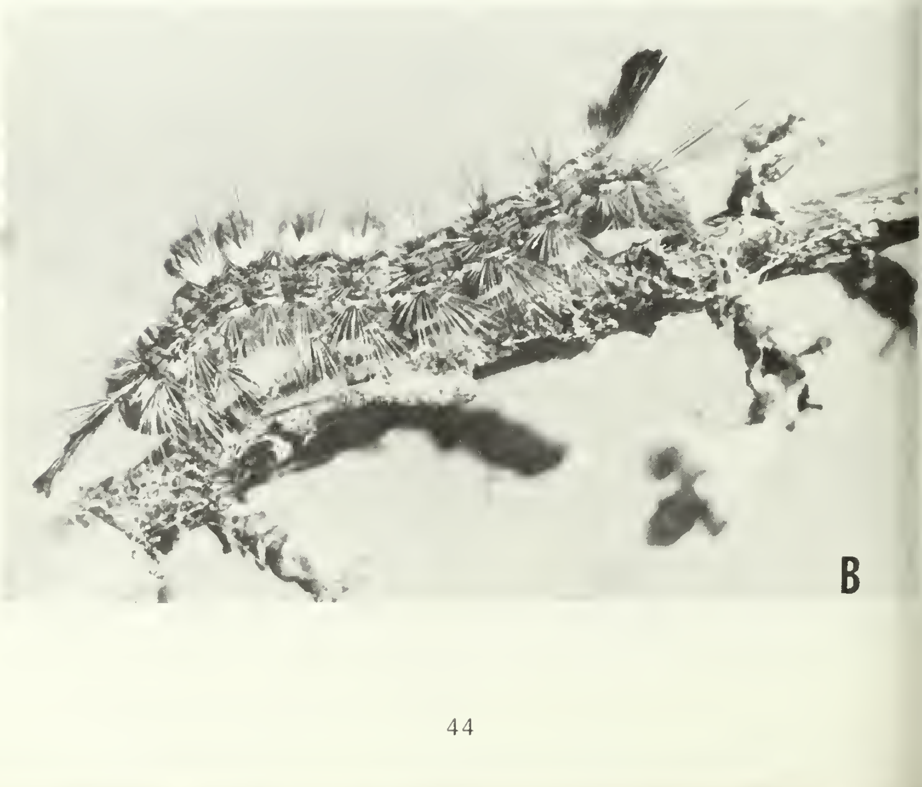


Figure 13.--The western tussock moth overwinters in egg masses (A) attached to Ceanothus velutinus *and other shrubs. The hairy caterpillars (B) are disseminated by wind when very young.*



sp., prob. *californicus* Ashm. (Scelionidae), and preyed on by a beetle, *Trogoderma sternale* Jayne var. (Dermestidae). Larvae are parasitized by three ichneumon wasps: *Iseropus orgyiae* (Ashw.), *Coccygomimus sanguinipes* (Cress.), and *Phobocampe* sp.; a braconid wasp, *Bracon xanthonotus* Ashm.; a pteromalid wasp, *Brachymeria ovata abiesae* (Gir.); and a tachnid fly, *Patelloa fusscimacula* Ald. and Webb. Pupae are preyed on by the anthocorid bug, *Lyctocoris campestris* (F.).

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Nymphalidae: Brush-footed Butterflies

Nymphalis antiopa Linnaeus: Morning-cloak butterfly

RANGE. Widely distributed; occurs throughout much of the Northern Hemisphere.

HOSTS. Mainly *Salix*, *Ulmus*, and species of *Populus* (especially *P. tremuloides* Michx.) but also recorded on *Betula*, *Alnus*, *Acer*, and rarely other trees.

DAMAGE. The newly hatched caterpillars skeletonize leaves but larger caterpillars devour all except the midrib. Occasionally, very severe defoliation occurs locally.

APPEARANCE AND HABITS. The orange-brown eggs are subcylindrical, ribbed, and rounded at their ends. They are laid in clusters of 20 or more, encircling a twig. The caterpillar (fig. 14) is black with short pale hairs and numerous long black forked spines. A single row of rich red

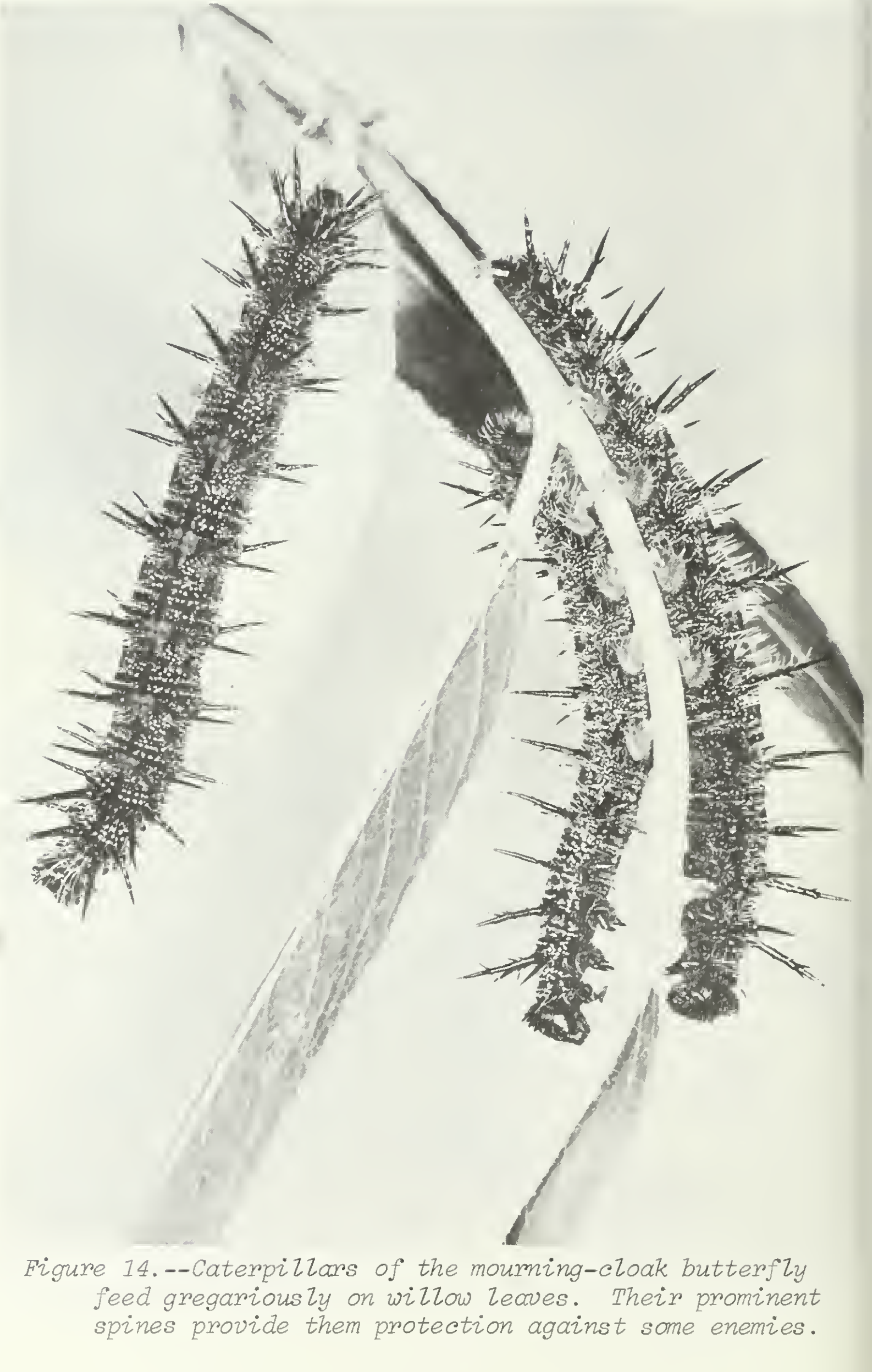

Figure 14.--Caterpillars of the mourning-cloak butterfly feed gregariously on willow leaves. Their prominent spines provide them protection against some enemies.

spots extends down the center of the back of the abdomen. The head of the caterpillar is round, black, and hairy. The thoracic legs are shiny black and the claspers on the prolegs are dull red. Newly hatched larvae feed side by side, with their heads toward the margin of the leaf. A silk thread is deposited by the caterpillars as they travel from leaf to leaf, making a sort of carpet. Eventually, this webbing becomes conspicuous and may bind together neighboring twigs. The pupa is 22 to 25 mm long, brown with gray or purple bloom, and its shape resembles that of the California tortoise-shell (see below). Like that species, the pupa hangs head downward, attached to the plant by silk to which it anchored its anal claspers while still a larva. Wingspan of the beautiful purple-black butterfly is 50 to 70 mm. The outer edges of the wings are bordered with a yellow stripe inside of which is a row of blue or purple spots. Two yellow spots occur toward the tip on the leading edge of the forewings.

LIFE CYCLE. Though the occurrence of multiple broods has been suggested, one generation per year seems to be normal over much of its range. The butterfly hibernates overwinter and appears in flight on sunny days during spring. Eggs are found during May and June, hatching in about 2 weeks. In northern areas, the caterpillars appear throughout the summer and pupae begin to appear in late June. Duration of the larval and pupal stages of an individual averages 4 and 2 weeks, respectively.

NATURAL CONTROL. Eggs of the mourning-cloak are parasitized by the scelionid wasp, *Telenomus graptae* Howard. Other wasps that parasitize caterpillars are reported to include the ichneumons, *Itoplectis conquisitor* (Say) and *Hoplismenus morulus morulus* (Say); the pteromalids, *Pteromalus fuscipes* (Provancher), *P. puparum* (Linnaeus), and *P. vanessae* Harris; and the chalcids, *Brachymeria compsilurae* (Crawford), and *B. ovata ovata* (Say).

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***Nymphalis californica* (Boisduval): California tortoise-shell**

RANGE. Throughout the Western United States; occasionally overwinters on Vancouver Island, British Columbia.

HOSTS. Most often, snowbrush (*Ceanothus velutinus*) and mountain whitethorn (*C. cordulatus*), but also recorded on *Amelanchier, Salix, Arctostaphylos,* wild lilac, other shrubs, and alfalfa.

DAMAGE. Destructive outbreaks have occurred on *Ceanothu* in many localities in northern California, especially during 1911, 1932, and 1951. In 1959, the caterpillars severely defoliated snowbrush in the Cascade Mountains of Oregon and, in 1959 and 1961, locally severe damage occurred in southwest Idaho.

APPEARANCE AND HABITS. The eggs are thought to be laid in a cluster, encircling a twig, as are those of *N. antiopa*. The caterpillar attains a length of 23 to 35 mm when mature. It is black with fine-branched spines on each segment. Down the middle of the back is a row of bright yellow spines mounted in blue tubercles, between which are numerous yellowish dots. The naked pupa (fig. 15) is 20 to 22 mm long, resembling a serrated crescent in shape, and with a rather shiny brown surface. It hangs downward, headfi attached to a branch by silk and its anal claspers. Stout points arise from the dorsal and lateral surfaces and from the front of the head. A sharp constriction between the thorax and abdomen contributes to a triangular shape of the forebody in lateral view. When disturbed, pupae thrash wildl from side to side. The butterfly (fig. 15) has a wingspan of 50 to 65 mm. Its color is brown and deep brown above, distinctly marked with black spots and border. The hind wings have a single large basal black spot and a submarginal row of purple spots. The undersurface is marbled fawn and various shades of brown with a narrow irregular submarginal purple line on both pairs of wings. During migration to and from its winter hibernation sites it has often attracted attention. One observer estimated that 600 butterflies per minute passed between two trees 50 feet apart.

LIFE CYCLE. There is a single generation per year. Eggs are laid in spring by adults that have hibernated overwinter. Larvae are present until the latter part of June to mid-July, at which time they pupate. Migrating adults begin to appear in late July and are abundant in early August.

NATURAL CONTROL. A multiple pteromalid parasite, *Pteromalus vanessae* How., commonly destroys pupae in Idaho. In California, adults have reportedly been fed on by the Brewer

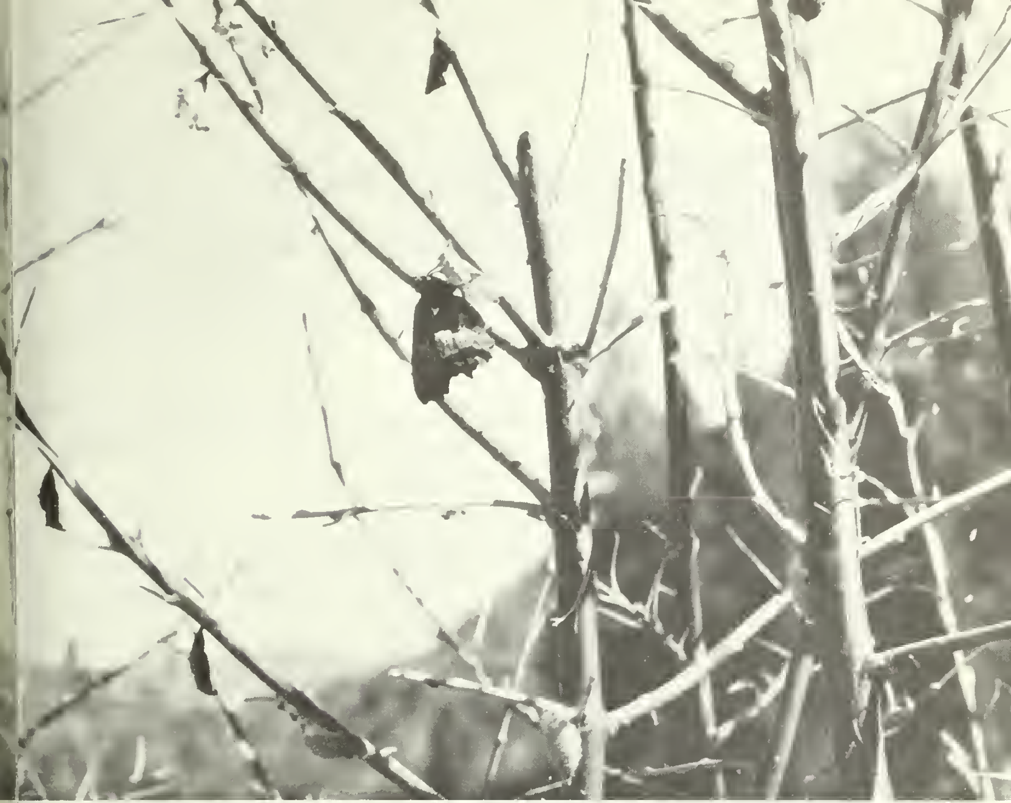

Figure 15.--A freshly emerged adult California tortoise shell butterfly hangs from its chrysalis on a defoliated shrub. Other chrysalids, and pupae, hang head downward from the branches.

blackbird, and caterpillars are eaten by ants and golden-mantled ground squirrels. Chipmunks have been seen eating the pupae. Severe hailstorms in the mountains during late summer probably take a toll of the migrating butterflies.

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Psychidae: Bagworm Moths

Apterona crenulella (Bruand) form *helix:* Snailcase bagworm

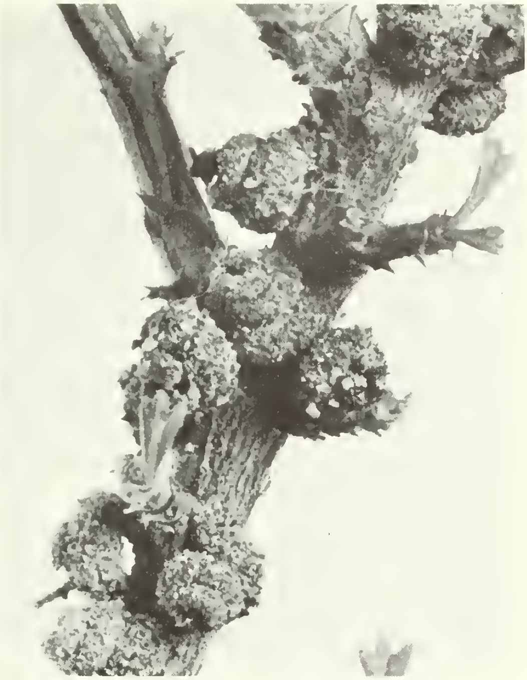
RANGE. Native to Europe; first found in the United States (in California) in 1940 and now occurs also in Nevada, Utah, and Idaho.

HOSTS. *Artemisia tridentata* Nutt., *Cercocarpus ledifoli* Nutt., and species of *Chrysothamnus*, *Salix*, *Atriplex*, and *Prunus* as well as many other plants.

DAMAGE. The most notable outbreak of this defoliator occurred in Box Elder County, Utah, during 1950-55, when 5,000 acres of rangeland were severely damaged. Substantial areas elsewhere in that State have also experienced outbreaks of the bagworm. In California, some commercial crops have been considerably damaged when populations were high. For example, 55 percent of the leaf surface of garden plants and 20 percent of the leaf surface of apple trees have been destroyed in local areas. At first, feeding by larvae creates concavities 1/32- to 1/16-inch diameter on either leaf surfac These increase to one-eighth inch as the larvae grow. Additi ally, larvae feed outward from these openings, creating a cavity between the leaf surfaces averaging one-fourth by three-eighth inch.

APPEARANCE AND HABITS. The egg is pale yellowish white, soft shelled, and somewhat elongate. From 10 to 30 eggs are laid per female. Newly hatched larvae are about 1 mm long, increasing to 6 to 7 mm at maturity. Larvae are greenis to reddish-gray with similar colored thoracic and anal plates. The head is nearly black. The thorax is robust, being at least twice the diameter of the tip of the tapered abdomen. The thoracic legs are very strong whereas the prolegs are reduced to crotchets and are nonfunctional. The larva is curled in shape. The snail-like case (fig. 16) is constructed by the larva with silk and soil particles. It contains a lateral opening in the upper whorl through which fecal matter is extruded. The case is held upright and the larva moves about with the forepart of the body projecting from the case. The pupa is 5 to 6 mm long, curved in a gentle spiral form, yellowish-brown and slightly diminished anteriorly. Only parthenogenetic females appear to have been introduced into the United States, although males occur in Europe. The adult female moth is wingless, nearly legless, and without functioni mouth parts, antennae or faceted eyes. She is in fact merely

Figure 16.--Snail-like cases containing larvae of Apterona crenulella *(Bruand) on bitterbrush.*



a specialized egg-laying device. Her body is 5 to 6 mm long, curved in a spiral form, and gray with brownish dorsal area. Sparse white hairs occur on the body with more dense lateral tufts near the tip of the abdomen.

LIFE CYCLE. The bagworm has one generation per year. Larvae overwinter within the pupal skin of the parent. They emerge to begin feeding in mid-April. During July, they seek out high points (fenceposts, buildings, and trees) on which to attach themselves over winter. Pupation, transformation to the adults, and reproduction all occur during July. Eggs hatch within 3 weeks.

References

Robinson, D. 1953. Garden bagworm, *Apterona crenulella (-Helix)* in Nevada and Placer Counties, California. The Bulletin, Calif. Dep. Agric. 42:1-9.

Kozhanchikov, I. V. 1956. Fauna of the U.S.S.R. Lepidoptera. Psychidae. Vol. III, No. 2. Zool. Inst. Acad. Sci. U.S.S.R., 525 p. (see p. 462-465). U.S. Dep. Commerce Transl. TT 69-55058.

Saturniidae: Giant Silkworm Moths

Hemileuca spp.: Buck moths and day moths

The taxonomy of these moths is confused and their biolog is not well known. Four of the better known species are described below.

APPEARANCE AND HABITS. Eggs are deposited in masses encircling a stem of the host plant. The larvae feed in colonies but do not spin tents. When caterpillars are numerous, plants are completely stripped of foliage. The caterpillars are mostly black, with various yellow or red markings depending on the species. Numerous branched urticating spine cause painful welts on contact with humans and severely infla the mouths of livestock if ingested. Some species of *Hemileu* spin a loose cocoon on the plant or in plant litter, but those referred to by some as *Pseudohazis* pupate in loose soil without a cocoon. Adults may hang in clusters on plants. Most species (including all = *Pseudohazis*) are day-flying moths with main flights occurring early in morning or late in afternoon.

LIFE CYCLE. Species that occur in warmer areas, such as *Hemileuca eglanterina* (Boisduval) (=*Pseudohazis*) in California, have one generation annually. The winter is spent as a first instar larva within the egg. Larval feeding occur during spring and summer. Pupation occurs in late summer and the adult moth emerges and oviposits in the fall. Specie such as *Hemileuca hera* Harris (=*Pseudohazis*) that inhabit cooler areas, have a 2-year life cycle. They hibernate as a first instar larva within the egg during the first winter, and as a pupa during the second winter. Adults are present generally from mid-July through August.

Hemileuca nevadensis Stretch: Nevada buck moth

RANGE. New Mexico, Arizona, California, and Idaho.

HOSTS. Mainly willow and poplar but may include a number of other deciduous trees and shrubs. Damage is sometim severe locally.

APPEARANCE. This moth has a white wing band occupying about half of the total wing area. Wingspan is 70 to 75 mm.

Hemileuca eglanterina (Boisduval) (=*Pseudohazis*): Pacific day moth.

RANGE. Subspecies *eglanterina*--California, Oregon, Washington, British Columbia, Montana, and northwestern Wyoming. Subspecies *shastaensis* (Grote)--limited to the southern part of the Cascade Mountains. The caterpillars cause economic damage to range shrubs and cultivated plants.

HOSTS. *Ceanothus* preferably; larvae feed on a wide variety of plants including *Salix, Arctostaphylos, Prunus, Rosa,* and fruit trees.

APPEARANCE AND HABITS. The moth has a wing expanse of 65 to 75 mm. Wings are yellow with conspicuous black markings including an eye-spot and an erratic outer band. A golden yellow stripe extends from the eye-spot of the front wing toward the margin. Moths appear in fall and fly in daytime. Eggs are orange color. The first instar larvae remain inside the eggs over winter and emerge in spring. Mature caterpillars are 50 to 60 mm long, dark brown, or dull black, with reddish dorsal spots and a narrow red line on each side. They are covered with stout, many branched, black and tan spines. Pupation occurs in plant litter.

NATURAL CONTROL. Larvae are parasitized by an ichneumon wasp, *Apanteles electrae* Vier.

Hemileuca hera hera (Harris) (=*Pseudohazis*): Great Basin day moth

RANGE: Throughout the Great Basin from the eastern slope of the Sierra Nevada to the Rockies, and from the Snake River into Arizona and New Mexico.

HOSTS. *Symphoricarpus,* which is often completely defoliated in areas of northern Utah; also commonly *Artemisia.*

APPEARANCE. The color of this moth is usually a rather clear, contrasting golden yellow and black, but white and black variations also occur. Near its eastward limit a very dark form predominates. It differs from *H. eglanterina* by lacking a golden stripe between the eye-spot and wing margin.

Hemileuca nuttalli nuttalli (Strecker) (= *Pseudohazis*): Nuttall's day moth

RANGE. From the Snake River northward in Idaho and eastward into western Wyoming and Montana.

HOSTS. *Artemisia*, preferably, which it often severely defoliates in the area south of West Yellowstone.

APPEARANCE. The forewings are basically lavender and black while the hind wings are golden yellow and black. A yellow stripe similar to that of *H. eglanterina* extends from the front eye-spot.

References

Essig, E. O. 1956. Insects of western North America. 1035 MacMillan Co., New York. (see p. 670-672)

Ferguson, Douglas C. 1971. In: Dominick, R. B., D. C. Ferguson, J. G. Franclemont, et al. The moths of Americ north of Mexico. Fasc. 20.2A. Bombycoidea. Saturniidae (Part). 153 p. E.W. Classey Ltd. and R.B.D. Publications, Inc., London.

Tortricidae: Leafroller Moths

Synnoma lynosyrana Walsingham: Rabbitbrush webbing moth

RANGE. Discontinuous in rangeland areas of the West. It is known from northern California, Idaho, Nevada, Utah, Arizona, Montana, Colorado, and New Mexico.

HOSTS. *Chrysothamnus nauseosus* (Pall.) Britt. and *C. viscidiflorus* (Hook.) Nutt.

DAMAGE. Defoliation by this insect is usually confined to local situations and rarely results in extensive plant mortality. Observations made in southern Idaho indicate that infestations can cause partial killing and weakening of plants especially green rabbitbrush.

APPEARANCE AND HABITS. Eggs are spherical, laterally flattened, about 0.4 mm in diameter, black with a somewhat granular surface. They are deposited in two-row masses in an overlapping fashion with approximately 100 eggs per mass.

They are most commonly located on small twigs or grass and debris on or at the base of the host plant. The larva is cream-colored, not conspicuously hairy, with the head and prothoracic shield brown. The mature larva is 18 to 24 mm long. The young larvae web leaves together and feed within the small webbing mass. As the larvae mature, more leaves as well as branches are webbed together. Six or more main stems may be enclosed in a webbing mass which can contain the webbing tunnels of up to eight larvae. The pupa is dark brown, 8-1/2 to 17 mm long. Pupation occurs in the webbing mass. Adults emerge only in the early morning and are active only during the day. Most of the body and wings are covered with orange to brown scales and hairs that are intermixed with white and black scales. Some of the dark scales on the wings are erect. The abdomen is black. The wing expanse is 15 to 22 mm. Gravid females are unable to fly.

LIFE CYCLE. Eggs overwinter and hatch in the early spring. Larvae are active throughout the spring and summer and pupation occurs from mid-August to mid-October and lasts approximately 6 weeks. Adults begin to emerge in late September and have been found active in the field as late as early November.

NATURAL CONTROL. Seven species of parasites have been found associated with the rabbitbrush webbing moth. The most important appear to be *Trichogramma minutum* Riley which is associated with the eggs and *Glypta* sp. and *Dibrachys cavus* (Walk.) which have been reared from the larvae.

Reference

Hawkes, R. B. 1962. Biology of *Synnoma lynosyrana* Walsingham in Idaho (Tortricidae: Lepidoptera). M.S. Thesis, Univ. Idaho, 51 p.

THYSANOPTERA: THRIPS

Thripidae: Common Thrips

Frankliniella occidentalis **(Pergande): Western flower thrips**

RANGE. Throughout western North America from sea level to subalpine altitudes.

HOSTS. Include *Purshia tridentata* (Pursh) DC.; nearly every flowering plant may be infested, especially the Leguminosae, Compositae, and Crucifera.

DAMAGE. This thrips enters bitterbrush flower buds and feeds on the developing parts of the flowers. Damage at this stage may prevent formation of some seed.

APPEARANCE AND HABITS. The opaque, reniform egg is inserted in the parenchyma cells of leaves, flower parts, and fruits. It hatches in 6 days at room temperature. The tiny first instar nymph emerges from the surface of the plant tissue headfirst and molts in about 3 days. The active secon instar nymph is golden yellow. After about 6 days the nymph undergoes two quiescent stages (pseudopupa). These last about a week and terminate in the adult stage. Adults vary in color, there being a pale form which is mostly white and yellow; an intermediate form which has an orange thorax and a brown abdomen; and a dark brown form. They are slender and about 1 mm long, with the wings narrow, fringed, and usually inconspicuous. They are secretive and seek the seclu provided by flowers. Their capacity to fly is limited. The adult initiates flight by first arching its abdomen upward. It then spreads its wings and releases its grip, causing it to be propelled end over end. It readily catches fast to whatever it strikes. The females reproduce either parthenogenetically, when they produce only males, or by mating with males.

LIFE CYCLE. Numerous generations occur annually, influen greatly by climate. In areas having a cold winter, the overwintering population tends to be adult females. A large increase in numbers of thrips occurs in spring with the resumption of warm weather and blossoming.

Reference

Bryan, Douglas E., and Ray F. Smith. 1956. The *Frankliniella occidentalis* (Pergande) complex in California (Thysanoptera: Thripidae). Univ. Calif. Publ. Entomol. 10:359-410.

IMPORTANT MITES

ACARINA: MITES AND TICKS

Eriophyidae: Gall Mites

Aceria kraftella **Keifer: Bitterbrush stem gall mite**

RANGE. California, Nevada, Oregon, Idaho, Montana, and British Columbia.

HOST. *Purshia tridentata* (Pursh) DC.

DAMAGE. Infestation by the mite causes irregular galls to form on current-year stems. Although the galls deform the branches (fig. 17), they are seldom abundant. The possibilit that infestation kills stems or causes them to become diseased has not been verified.

APPEARANCE AND HABITS. The immature stages and the mite's habits have not been described. The mites can be observed only under magnification. They are minute (less than 0.3 mm long), and lack coloration, and have only two pairs of legs at the anterior end. The abdomen is elongated, finely striated with concentric lines, and terminates in two long spines.

LIFE CYCLE. The life cycle has not been studied. Other eriophyid mites have immature and adult stages present over winter and a number of uneven broods resulting from continuous breeding during summer. The mite apparently emerges from stem galls in spring and infests new branch growth.

Reference

Keifer, H. H. 1959. Eriophyid studies XXVI. Bull. Calif. Dep. Agric. 47:271-281.

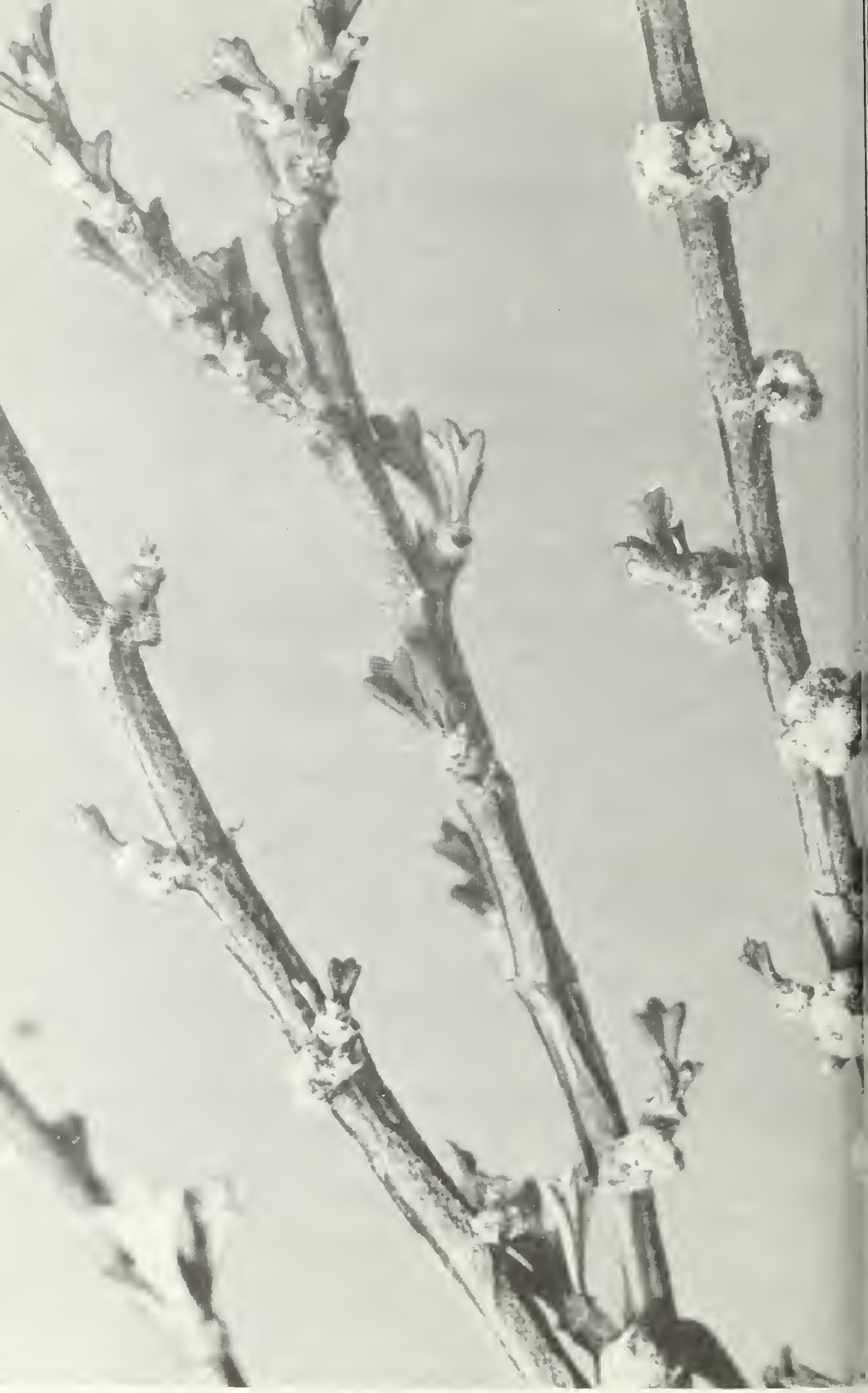


Figure 17.--Stem galls made by the mite; Aceria kraftella *Kiefer, on bitterbrush.*

HOST PLANT INDEX

Page

- *Acer* spp.
  - LEPIDOPTERA
    - Lasiocampidae
      - *Malacosoma distria* Hübner 38
    - Nymphalidae
      - *Nymphalis antiopa* Linnaeus 45

- *Alnus* spp.
  - COLEOPTERA
    - Buprestidae
      - *Agrilus* spp. 4
      - *Dicerca horni* Crotch 7
    - Chrysomelidae
      - *Altica ambiens* (LeConte) 10
    - Curculionidae
      - *Sternochetus lapathi* (Linnaeus) 14
  - LEPIDOPTERA
    - Lasiocampidae
      - *Malacosoma distria* Hübner 38
      - *M. californicum pluviale* (Dyar) 40
    - Nymphalidae
      - *Nymphalis antiopa* Linnaeus 45

- *Amelanchier* spp.
  - COLEOPTERA
    - Buprestidae
      - *Anthaxia* spp. 6
    - Scolytidae
      - *Chaetophloeus heterodoxus* (Casey) 16
  - HOMOPTERA
    - Diaspididae
      - *Lepidosaphes ulmi* (Linnaeus) 26
  - LEPIDOPTERA
    - Lasiocampidae
      - *Malacosoma californicum* (Packard) 40
    - Nymphalidae
      - *Nymphalis californica* (Boisduval) 47

Page

Arctostaphylos spp.
- COLEOPTERA
  - Buprestidae
    - *Acmaeodera* spp. 3
    - *Agrilus* spp. 4,5
- LEPIDOPTERA
  - Lymantriidae
    - *Hemerocampa vetusta gulosa* (Boisduval) . . 42
  - Nymphalidae
    - *Nymphalis californica* (Boisduval) 47
  - Saturniidae
    - *Hemileuca eglanterina* (Boisduval) 52,53,54

Artemisia spp.
- COLEOPTERA
  - Cerambycidae
    - *Crossidius* spp. 7,8
    - *Trirhabda pilosa* Blake 11
- DIPTERA
  - Tephritidae
    - *Eutreta* spp. 20
- HOMOPTERA
  - Ortheziidae
    - *Orthezia artemisiae* Cockerell 28
- HYMENOPTERA
  - Formicidae
    - *Pogonomyrmex occidentalis* (Cresson) . . . 28
    - *P. owyheei* Cole 28
- LEPIDOPTERA
  - Gelechiidae
    - *Aroga websteri* Clarke 30
  - Saturniidae
    - *Hemileuca hera hera* (Harris) 52
    - *H. nuttalli nuttalli* (Strecker) 54
  - Psychidae
    - *Apterona crenulella* (Bruand) 50

Atriplex spp.
- LEPIDOPTERA
  - Psychidae
    - *Apterona crenulella* (Bruand) 50

Betula spp.
- COLEOPTERA
  - Curculionidae
    - *Sternochetus lapathi* (Linnaeus) 14

Page

Betula spp. (con.)
  LEPIDOPTERA
    Lasiocampidae
      Malacosoma distria Hübner 38
    Nymphalidae
      Nymphalis antiopa Linnaeus 45

Ceanothus spp.
  COLEOPTERA
    Buprestidae
      Acmaeodera spp. 3
      Anthaxia spp. 6
      Dicerca horni Crotch 7
  LEPIDOPTERA
    Lasiocampidae
      Malacosoma californicum Packard 40
    Nymphalidae
      Nymphalis californica (Boisduval) . . . 47
    Saturniidae
      Hemileuca eglanterina (Boisduval) . . . 53

Cercocarpus spp.
  COLEOPTERA
    Buprestidae
      Acmaeodera spp. 3
      Anthaxia spp. 6
      Dicerca horni Crotch 7
    Scolytidae
      Chaetophloeus heterodoxus (Casey) . . . 16
  LEPIDOPTERA
    Ethmiidae
      Ethmyia discostrigella (Chambers) . . . 29
    Lasiocampidae
      Malacosoma californicum (Packard) . . . 40
    Psychidae
      Apterona crenulella (Bruand) 50

Chrysothamnus spp.
  COLEOPTERA
    Buprestidae
      Agrilus spp. 4
    Cerambycidae
      Crossidius spp. 7
      Trirhabda lewisii Crotch 11
  DIPTERA
    Tephritidae
      Aciurina spp. 20
      Procecidochares spp. 20

Page

Chrysothamnus spp. (con.)
  LEPIDOPTERA
    Psychidae
      Apterona crenulella (Bruand) 50
    Tortricidae
      Synnoma lynosyrana Walsingham 54

Populus spp.
  LEPIDOPTERA
    Lasiocampidae
      Malacosoma distria Hübner 38
      M. californicum (Packard) 40
    Nymphalidae
      Nymphalis antiopa Linnaeus 45
    Saturniidae
      Hemileuca nevadensis Stretch 52

Prunus spp.
  COLEOPTERA
    Buprestidae
      Anthaxia spp. 6
      Dicerca pectorosa LeConte 7
    Scolytidae
      Chaetophloeus heterodoxus (Casey) 16
  LEPIDOPTERA
    Psychidae
      Apterona crenulella (Bruand) 50
    Saturniidae
      Hemileuca eglanterina (Boisduval) 52,53

Purshia tridentata (Pursh) DC.
  COLEOPTERA
    Buprestidae
      Acmaeodera spp. 3
      Anthaxia spp. 6
  DIPTERA
    Cecidomyiidae
      Mayetiola sp. 18
  HEMIPTERA
    Pentatomidae
      Chlorochroa sayi (Stäl) 22
  HOMOPTERA
    Coccidae
      Lecanium cerasifex Fitch 24

Page

Purshia tridentata (Pursh) DC. (con.)
- LEPIDOPTERA
  - Gelechiidae
    - *Filatima sperryi* Clarke 32
    - *Gelechia mandella* Busck. 32,33
  - Geometridae
    - *Anacamptodes clivinaria profanata* (Barnes and McDunnough) 34
  - Lasiocampidae
    - *Malacosoma californicum* (Packard) . . . 40
  - Lymantriidae
    - *Hemerocampa vetusta gulosa* (Boisduval) . 42
- THYSANOPTERA
  - Thripidae
    - *Frankliniella occidentalis* (Pergande). . 55
- ACARINA
  - Eriophyidae
    - *Aceria kraftella* Keifer 57

Quercus spp.
- COLEOPTERA
  - Buprestidae
    - *Acmaeodera* spp. 3
    - *Agrilus* spp. 4
    - *Anthaxia* spp. 6
- LEPIDOPTERA
  - Lasiocampidae
    - *Malacosoma distria* Hübner 38
    - *M. constrictum* (Henry Edwards) 41
  - Lymantriidae
    - *Hemerocampa vetusta gulosa* (Boisduval) . 42

Ribes spp.
- LEPIDOPTERA
  - Lasiocampidae
    - *Malacosoma californicum* (Packard) . . . 40

Rosa spp.
- COLEOPTERA
  - Buprestidae
    - *Acmaeodera* spp. 3
    - *Anthaxia* spp. 6
  - Curculionidae
    - *Rhynchites bicolor* (Fabricius) 13
- HOMOPTERA
  - Diaspididae
    - *Lepidosaphes ulmi* (Linnaeus) 26

Page
Rosa spp. (con.)
LEPIDOPTERA
Lasiocampidae
Malacosoma californicum (Packard) 40
Saturniidae
Hemileuca eglanterina (Boisduval) 52,53

Salix spp.
COLEOPTERA
Buprestidae
Agrilus spp. 4
Anthaxia spp. 6
Chrysomelidae
Altica bimarginata Say 10
Disonycha latiovittata Hatch 11
Curculionidae
Sternochetus lapathi (Linnaeus) 14
HOMOPTERA
Diaspididae
Lepidosaphes ulmi (Linnaeus) 26
LEPIDOPTERA
Lasiocampidae
Malacosoma distria Hübner 38
M. californicum (Packard) 40
M. californicum pluviale (Dyar) 40
Lymantriidae
Hemerocampa vetusta gulosa (Boisduval). . 42
Nymphalidae
Nymphalis antiopa Linnaeus 45
N. californica (Boisduval) 47
Psychidae
Apterona crenulella (Bruand) 50
Saturniidae
Hemileuca nevadensis Stretch 52
H. eglanterina (Boisduval) 52,53

Sambucus spp.
COLEOPTERA
Cerambycidae
Desmocerus spp. 9

Symphoricarpos spp.
LEPIDOPTERA
Saturniidae
Hemileuca hera hera (Harris) 53

Ulmus spp.
LEPIDOPTERA
Nymphalidae
Nymphalis antiopa Linnaeus 45

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FURNISS, MALCOLM M., and WILLIAM F. BARR
1975. Insects affecting important native shrubs of the northwestern United States. USDA For. Serv. Gen. Tech. Rep. INT-19, 64 p., illus. (Intermountain Forest & Range Experiment Station, Ogden, Utah 84401.)

Information is presented on insects and mites associated with important shrubs native to the Pacific Northwest. Forty-three insect species or insect groups and one mite species are discussed with emphasis placed on their geographic range, hosts, type of damage, appearance and habits, life cycle, and natural control.

OXFORD: 181.1; 114.68.
KEYWORDS: native shrubs, insects, Pacific Northwest, browse-plants, game browse, natural control.

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Headquarters for the Intermountain Forest and Range Experiment Station are in Ogden, Utah. Field Research Work Units are maintained in:

- Boise, Idaho
- Bozeman, Montana (in cooperation with Montana State University)
- Logan, Utah (in cooperation with Utah State University)
- Missoula, Montana (in cooperation with University of Montana)
- Moscow, Idaho (in cooperation with the University of Idaho)
- Provo, Utah (in cooperation with Brigham Young University)
- Reno, Nevada (in cooperation with the University of Nevada)

PHOTOS

Front Cover: Normal-appearing mountain mahogany shrub, Juniper Mountain, Owyhee Co., Idaho.

Inside Front Cover: Mountain mahogany defoliated by the looper, Anacamptodes clivinaria profanata *(B. & McD.).*

Outside Back Cover: Bull elk feeding on serviceberry on winter range, Lochsa River, Idaho. (Idaho Fish & Game Department photo by Thomas A. Leege.)

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